Nuclear Resonance

Nuclear resonance flowmeters, as described by Replogle (8), exploit a property of molecular nuclei. In nuclear resonance, the nucleus is disturbed by precessional motions, which have a negligible effect upon molecular or chemical reactions. Essentially, nuclear resonance consists of observing the absorption of radio waves at a frequency determined by the ratio of the nuclear magnetic moment to its spin (called the gyromagnetic ratio) and the value of an applied magnetic field. In water molecules, it is particularly easy to observe nuclear resonance since hydrogen protons provide a very strong absorption signal. Resonance is observed by using a receiver to detect the rf energy lost from a transmitter. No resonance signal can then be detected until the transmitter power is reduced and sufficient time has elapsed so that the nuclei can relax to their normal distribution. This relaxation time is a characteristic of the nuclei and their environment and may be used to indicate the velocity of flowing fluids.

In the somewhat limited work that has been done, accuracies of ±0.5% of full scale have been achieved over a 10:1 range under full pipe flow conditions. This technique does not appear suitable for storm or combined sewer application at this time and, consequently, will not be discussed further.

Miscellaneous

It should not be supposed that the foregoing discussion has exhausted the possibilities of physical principles or design adaptations for measuring fluid flows. There are numerous other devices or methods such as: the Gibson (or water hammer) technique that requires the sudden closure of a valve or gate and pressurized pipe flow; Andersson screens, which require a reach of very regular channel and a track on which the screen car can travel; Danaides devices, in which flow rate is related to the depth of the liquid in a container which is discharging through calibrated orifices; fixed measuring palisades that consist of airfoil-shaped vanes extending across the flow and creating a differential pressure that is related to discharge; the closely related tilting palisades in which the flow is determined from the force required to prevent the palisade from tilting from the vertical; and so on.

These all have, in the writers' opinion, one or more limitations, when considered for a storm or combined sewer application, that are so severe as to make any adaptation of them unpractical. Therefore, they are not discussed at all.

SECONDARY DEVICES

A review of all of the secondary devices used in flow measurement is outside the scope of the present writing. There do exist, however, a number of devices that are called flowmeters by their manufacturers but which, in actuality, are secondary devices for measuring stage. They must be used with some form of primary device before true flow measurements can be made. A brief discussion of these devices will be given along generic lines.

As is the case with all secondary devices, there are three basic types of information that can be provided, either separately or in combination. These are an indication of flow rate (typical units are cfs, gph, mgd, etc.; such devices are sometimes referred to as indicators); a running total of flow to the observed moment (typical units are cu. ft., gal., m.g., etc.; such devices are sometimes called totalizers); and a record, ranging from a curve drawn in ink with a pen to a magnetic tape recording, of the rate of flow with time over some suitable period (hour, day, week, etc.; such devices are termed recorders). Additional features may include the ability to transmit the flow data to a remote site (transmitters, the corresponding instruments at the other end being termed receivers), the ability to operate in digital versus analog form, etc. The discussions will not deal with these topics, but will focus upon the method used to sense or measure water level or stage.

Float-in-Well. This is probably the oldest type of secondary device in existence. It is applied in a stilling well connected to the gage point of the primary device (weir, flume, etc.). The float-in-well essentially consists of a float of some suitable shape (sized for compatibility with the dimensions of the well) connected via a cable to a wheel and counterbalanced in some fashion so that the cable remains taut. As the float rises or falls with charges in water level, the cable rotates the wheel, which is connected either mechanically or electronically to the readout, recorder, or whatever. Discharge is determined by the use of cams, electronic circuits, etc., that are characterized for the primary device involved.

Float-in-Flow. In this type of secondary device, the float rides on the actual surface of the flow, directly sensing its level rather than indirectly sensing it as with a stilling well. Float shapes range from spherical, to scow or ski shaped, the latter being designed to minimize disturbances of the liquid surface, fouling by trash or debris, oscillations in the instrument, etc. The float is attached to a hinged arm that is directly or indirectly (e.g., by cable) connected to the main body of the instrument. Directly-connected designs should be immersion proof if they are to be used in storm or combined sewers with any history of surcharging. In indirectly-connected designs, where the main body of the instrument can be located above the high water level, it need not necessarily be immersion proof, but this feature never hurts.

Advantages of float-in-flow devices include: freedom from the requirement for a stilling well and purge system; direct (rather than indirect) sensing of the liquid level; and avoidance (in some designs) of cables, counterweights, etc., typical of float-in-well devices. Disadvantages include: possible fouling by trash or debris (which can result in erroneous readings or even physical damage); broad chart records in some instances due to the lack of damping of water surface oscillations that some stilling wells provide; and a more limited range due to the restrictions on arm length necessary at some installations.

Bubbler. In this type secondary device, a pressure transducer senses the back-pressure experienced by a gas which is bubbled at a constant flow rate through a tube anchored at an appropriate point with respect to the primary device. This back-pressure can be translated into water depth and subsequently related to discharge. Advantages include a lack of moving parts or mechanisms, a sort of self-cleaning action arising from the gas flow, and virtually no obstruction to the flow. One of its main disadvantages is that if the exit end base of the bubble tube becomes appreciably reduced due to build-up of contaminants from the flow, erroneous readings will result even though the instrument may appear to be functioning normally. Aspiration effects due to the velocity of the flow may also present problems.

Electrical. These secondary devices make use of some sort of change in electric circuit characteristics in order to indicate the liquid level. Most designs utilize a probe or some similar sensor which is immersed in the flow at the gage point. This sensor is a part of an electrical circuit, and its behavior in the circuit is a function of its degree of immersion. For example, the sensor could basically be an admittance-to-current transducer, providing a measure of depth based on the small current flowing from the sensor to the grounded stream. Changes in any electrical property (capacitance, resistance, etc.) can be used to sense liquid depth. Advantages are the absence of any moving parts, floats, cables, stilling wells, gas supplies, purge requirements and the fact that they cannot plug and are usually unaffected by build-up of sludge, algae, slime, mud, etc. The major disadvantage is the requirement for the sensing element to physically be in the flow. The presence of appreciable foam or floating oil and grease can cause errors in most designs.

In a somewhat different design belonging to this class, the probe is not actually in the stream but is periodically lowered, via a motor-pulley-cable arrangement, until it makes contact with the water surface, which completes a microampere circuit through the liquid to a ground return.

This signal reverses the motor, raising the probe above the surface of the liquid. As in the case with a float, the amount of cable paid out is the measure of stage. Although this design does not require immersion of the sensor in the flow, it does involve mechanical complexities and moving parts not characteristic of the other electrical secondary devices.

Acoustic. This type of secondary device is growing in popularity as prices decrease. Requiring no physical contact with the liquid, they enjoy all of the advantages listed for electronic designs. They were covered in the discussion of acoustic primary devices and will not be redescribed here. However, a few precautionary words will be given. For applications where space is restricted as in some manholes and small meter vaults, problems due to false echos may be encountered. This problem may be overcome at some sites by shielding the transducer, but accurate readings (at low flows at least) should not be expected for flows in round pipes or deep, narrow channels from most designs. Also, good results should not be expected if the surface of the flow is highly turbulent or foam covered as the reduced return signal may not be properly detected.

DISCUSSION

The evaluation tables of the various flow measuring devices and techniques are summarized in matrix form in Table 40. It is re-emphasized that these evaluations are made with a storm or combined sewer application in mind and will not necessarily be applicable for other types of flows.

Table 41 offers a different (and even more subjective) comparison of some of the primary devices or techniques that are currently being used to measure storm and combined sewer discharges. Each method is numerically evaluated in terms of its percent of achievement of several desirable characteristics. Dilution techniques as a class appear to be the most promising of all. In view of the current state of the art, however, their usefulness is probably greatest as a tool for in-place calibration of other primary devices. They have also been extremely useful for general survey purposes and have found some application as an adjunct to other primary devices during periods of extreme flow such as pressurized flow in a conduit that is normally open channel.

Acoustic open channel devices are also quite promising; but, because of their dependency upon the velocity profile and the frequently resulting requirement for several sets of transducers, they are presently only justifiable for very large flows in view of the expense involved. The usefulness of the Parshall flume is evidenced by its extreme popularity. The requirement for a drop in the flow is a disadvantage, and submerged operation may present problems at some sites. Known uncertainties in the head-discharge relations (possibly up to 5%) together with possible geometric deviations make calibration in place a vital necessity if high accuracy is required. Palmer-Bowlus type flumes are very popular

TABLE 40. FLOWMETER EVALUATION SUMMARY

	Range	Accuracy	Flow Effects on Accuracy	Gravity & Pressurized Flow Operations	Submergence or Backwater Effects	Effect of Solids Movement	Flow Obstruction	Head Loss	Manhole Operation	Power Requirements	Site Requirements	Installation Restrictions or Limitations	Simplicity and Reliability	Unattended Operation	Maintenance Requirements	Adverse Ambient Effects	Submersion Proof	Ruggedness	Self Contained	Precalibration	Ease of Calibration	Maintenance of Calibration	Adaptability	Cost	Portability
Gravimetric-all types	G	G	H	Y	L	H	H	H	P	M	H	H	P	Y	M	M	-	F	Y	Y	G	F	-	H	N
Volumetric-all types	P	G	H	Y	L	H	H	M	P	L	M	H	F	Y	M	M	-	F	Y	Y	G	F	-	M	N
Venturi Tube	P	G	S	N	L	S	S	L	P	L	M	H	G	Y	M	M	-	G	Y	Y	G	G	-	M	N
Dall Tube	P	G	S	N	L	M	S	L	P	L	H	M	G	Y	M	M	-	G	Y	Y	G	F	-	M	N
Flow Nozzle	P	G	S	N	L	S	S	M	P	L	H	M	G	Y	L	M	-	G	Y	Y	G	G	-	M	N
Orifice Plate	P	F	S	N	L	H	M	H	P	L	H	S	G	Y	H	M	-	F	Y	Y	G	P	-	L	Y
Elbow Meter	P	F	S	N	L	S	S	L	P	L	H	S	G	Y	L	M	-	G	Y	N	F	G	-	L	N
Slope Area	F	P	M	N	H	S	S	L	G	L	M	S	G	Y	L	M	-	G	Y	N	F	G	-	H	N
Sharp-Crested Weir	F	F	M	N	M	H	H	H	F	L	M	M	G	Y	H	M	-	G	Y	Y	G	P	-	L	Y
Broad-Crested Weir	F	F	S	N	H	M	M	M	G	L	M	M	G	Y	L	M	-	G	Y	N	F	F	-	L	N
Subcritical Flume	F	F	S	N	L	S	S	L	F	L	M	S	G	Y	L	M	-	G	Y	Y	G	G	-	M	N
Parshall Flume	G	F	S	N	M	S	S	L	F	L	M	M	G	Y	L	M	-	G	Y	Y	G	G	-	M	Y
Palmer-Bowlus Flume	F	F	S	N	M	S	S	L	G	L	S	S	G	Y	L	M	-	G	Y	Y	G	G	-	L	Y
Diskin Device	F	F	S	N	M	M	H	L	G	L	S	S	G	N	H	H	-	F	Y	Y	F	F	-	L	Y
Cutthroat Flume	G	F	S	N	L	S	S	L	P	L	S	S	G	Y	L	M	-	G	Y	Y	G	G	-	L	N
San Dimas Flume	G	F	S	N	L	S	S	L	F	L	S	S	G	Y	L	M	-	G	Y	Y	G	G	-	L	N
Trapezoidal Flume	G	F	S	N	L	S	S	L	F	L	S	S	G	.Y	L	M	-	G	Y	Y	G	G	-	L	N
Type HS, H & HL Flume	G	F	S	N	H	M	S	H	G	L	M	M	G	Y	M	H	-	G	Y	Y	G	F	-	L	Y
Open Flow Nozzle	G	F	S	N	H	M	S	H	G	L	M	M	G	Y	M	M	-	G	Y	Y	G	F	-	L	Y
Float Velocity	G	P	H	N	L	S	S	L	G	L	S	S	G	N	L	H	-	G	N	-	-	-	-	L	Y
Tracer Velocity	F	F	M	Y	L	S	S	L	G	M	S	S	F	Y	M	S	-	F	N	N	G	G	-	H	Y
Vortex Velocity	P	F	S	N	L	H	M	L	P	L	H	H	F	Y	M	S	-	P	Y	Y	F	F	-	H	N
Eddy-Shedding	F	F	S	Y	L	M	M	L	G	L	S	S	F	Y	M	S	-	F	Y	Y	G	F	-	M	Y
Turbine Meter	P	F	S	N	L	H	H	M	P	L	H	M	F	Y	H	S	-	F	Y	Y	G	F	-	H	N
Rotating-Element Meter	F	F	S	Y	L	M	M	L	F	L	S	S	G	N	M	M	-	G	N	Y	G	G	-	L	Y
Vane Meter	P	F	S	N	L	M	H	L	F	L	S	M	G	Y	M	M	-	G	Y	Y	F	F	-	L	N
Hydrometric Pendulum	P	P	S	N	L	M	M	L	G	L	S	S	G	N	L	H	-	G	N	Y	F	F	-	L	Y
Target Meter	P	F	S	N	L	M	H	M	P	M	S	M	F	Y	H	S	-	P	Y	Y	G	F	-	H	N
Force-Momentum	P	G	S	N	L	M	M	L	P	H	H	H	P	Y	H	S	-	P	Y	Y	G	G	-	M	N
Hot-Tip Meter	F	P	S	Y	L	H	M	L	F	M	M	M	F	Y	H	M	-	F	Y	Y	G	F	-	M	N
Boundary Layer Meter	G	G	S	Y	L	S	S	L	P	M	M	M	F	Y	M	S	-	G	Y	Y	G	G	-	H	N
Electromagnetic Meter	F	G	S	Y	L	S	S	L	P	H	M	M	F	Y	M	S	-	F	Y	Y	G	G	-	H	N
Acoustic Meter	G	G	S	Y	L	M	S	L	F	M	M	M	F	Y	M	S	-	F	Y	Y	G	G	-	H	N
Doppler Meter	P	G	S	Y	L	M	S	L	F	M	M	M	F	Y	M	S	-	F	Y	Y	G	G	-	H	N
Optical Meter	F	P	S	N	L	S	S	L	F	L	S	S	G	N	L	H	-	G	N	Y	G	G	-	L	Y
Dilution	G	G	M	Y	L	S	S	L	G	M	S	S	F	Y	M	S	-	F	N	N	G	G	-	H	Y

Legend

F - Fair
G - Goal
H - High
L - Low
M - Medium or Moderate
N - No
P - Poor
S - Slight
Y - Yes

TABLE 41. COMPARISON OF MOST POPULAR PRIMARY DEVICES OR TECHNIQUES

Primary Device or Technique	Desirable Characteristic (% of Achievement)								Comments
	Range	Uncalib. Accuracy	Head Loss	Free From Upstream Effects	Free From Downstream Effects	Solids Bearing Liquids	Portability	Unattended Operation	
Dilution	100	100	100	100	100	100	100	80	Especially useful as a calibration tool.
Acoustic (Open Channel)	100	100	100	60	90	95	80	100	Good in large flows but expensive
Parshall Flume	90	95	80	90	80	90	70	100	Requires drop in floor.
Palmer Bowlus Flume	80	90	85	90	85	90	90	100	Good overall.
Current Meter	90	95	100	100	100	90	100	0	Results are very operator dependent.
Electromagnetic	50	100	100	100	100	100	0	100	Generally requires pressure flow
Acoustic (Pressure Flow)	100	100	100	60	90	95	0	100	Wetted transducers recommended
Open Flow Nozzle	60	95	70	80	75	80	80	95	Good if head drop is available.
Sharp-Crested Weir	60	95	70	80	80	50	80	90	Will require frequent cleaning
Flow Tube	50	100	95	40	100	95	0	100	Pressurized flow only.
Venturi Tube	20	100	90	70	100	90	0	100	Pressurized flow only.
Trajectory Coordinate	80	70	50	100	70	100	100	0	Requires free discharge
Slope Area	80	50	100	20	100	100	100	0	Use as last resort.

3411-1A

overall. They can be used as portable as well as fixed devices in many instances, are relatively inexpensive, and can handle solids in the flow without great difficulty.

All point velocity measuring devices have been lumped together in the current meter category. In the hands of a highly experienced operator, good results can be obtained (the converse is also true, unfortunately), and they are often used to calibrate primary devices in place or for general survey work. They are generally not suited for unattended operation in storm and combined sewer flows, however.

Electromagnetic flowmeters show considerable promise where pressurized flow is assured as do closed pipe acoustic devices. Neither can be considered portable if one requires that the acoustic sensors be wetted, a recommended practice for most wastewater applications.

Open flow nozzles and sharp-crested weirs are often used where the required head drop is available. Weirs will require frequent cleaning and are best used as temporary installations for calibration purposes. Flow tubes and venturis are only suitable for pressurized flow sites such as might be encountered, for example, at the entrance to a treatment plant.

Trajectory coordinate techniques, such as the California pipe or Purdue methods, require a pipe discharging freely into the atmosphere with sufficient drop to allow a reasonably accurate vertical measurement to be made, a situation not often encountered in storm or combined sewers. Slope area methods, as explained earlier, must generally be considered as producing estimates only and, consequently should be considered as the choice of last resort (despite their apparent popularity).

SECTION VII

REVIEW OF COMMERCIALLY AVAILABLE EQUIPMENT

The number of commercial firms that offer flow measuring or related equipment in the market place today is astoundingly large. Even when attention is limited to devices intended for liquid flowmetering, the number is still extremely large, probably well in excess of two hundred. Many manufacturers offer more than one type of primary device (and these typically in numerous models), and when combined with secondary device choices, the possible number is virtually overwhelming. Thus, complete coverage in a document of this sort is impossible.

The intent of this section is not, therefore, to provide a complete catalog which lists all manufacturers and discusses all their offerings. Rather an attempt has been made to select a large enough sampling of firms and products and describe each of these briefly but in enough detail to allow the reader to appreciate the actual implementation of the generic flow measurement methods discussed in Section VI. In accomplishing this, well over 120 manufacturers were contacted regarding product lines which might be recommended for application to the measurement of sewer flows. These firms ranged from very large, well known manufacturers that have offered a wide range of flow measuring equipment for over a century to relatively small organizations with a limited product line which has only recently been introduced. Devices were included which either illustrated one of the generic flow measurement methods or appeared to embody some novel or interesting implementation or variation. Even at that, there have undoubtedly been omissions, and some manufacturers of applicable equipment may have been overlooked. For this the writers wish to apologize and urge any firm that feels it has equipment suitable for sewer flow measurement (or has refined or improved its products) to communicate this information to them so that it might be included in any possible future update of this work.

The common format that has been followed in describing the commercially available equipment is straightforward and needs no explanation. However, a few comments on the information presented are needed. All information for a particular piece of equipment, including specifications, special claims for it, etc., has been taken from material supplied by its manufacturer in the form of descriptive brochures, specification sheets, technical writeups, user manuals, private correspondence, etc. It was not possible for the writers to verify or authenticate any of this information, so it must be accepted as manufacturer's claims only.

A comment on prices must also be made. Many manufacturers prefer to quote on an application basis. In view of this and the general economic conditions at the time of this writing (Fall 1974), prices where given should be considered approximations and should be verified with the particular manufacturer before using, even for general budgetary purposes. For example, one manufacturer who was contacted had just received a 25 percent increase from his forging contractor and could not tell what overall effect this would have on his prices; many suppliers are quoting prices on a delivery basis; etc. Because of this situation, attempts to obtain pricing information were curtailed; thus, some manufacturer's products have no prices given.

All illustrations in this section were taken from photographs, brochures, or other material provided by the respective manufacturers, and deep appreciation for permission to use them in this report is hereby acknowledged.

ALPHABETICAL LIST OF MANUFACTURERS

MANUFACTURER: AMERICAN CHAIN AND CABLE COMPANY, INC.
ACCO BRISTOL DIVISION
WATERBURY, CONNECTICUT 06720
TELEPHONE (203) 756-4451

PRODUCT LINE: FLOWMETERING SYSTEM

DESCRIPTION:

The Bristol Series 840 L/V Monitoring System is designed to measure the level and velocity of sewer flow in larger (over 1m) sewer conduits. It is engineered primarily for manhole installation, can be positioned at existing manholes, and can be moved from one manhole to another for the purpose of making surveys of a sewage system. The monitoring system, shown in Figure A, consists of three major subassemblies: monitor assembly, probe controls, and a probe operator or hoist assembly. A single, self-cleaning probe is used for both velocity and flow level measurement. It is designed to withstand the corrosive environment of a sewer system and the impact of heavy objects.

The velocity of the flowing liquid is determined by a drag-type primary element which is located within the probe assembly. A hermetically-sealed flexure assembly is fastened to a cylindrical "target" area and contains a four-arm strain gage bridge together with the necessary compensating networks. As the moving stream impinges on the target area, an impact force is developed which is proportional to the square of the velocity of the stream. The impact force causes a linear deflection of the flexure, which is detected by the strain gage bridge. An excitation voltage from the strain gage power supply feeds the velocity sensor. Calibration is such that velocity of 0 to 3 m/s (0 to 10 fps) corresponds to an output signal of 0 to 20 mV. Thus, the force exerted on the target area is converted to an electrical output signal from the strain gage sensor. This millivolt signal is then amplified (in the Probe Controls cabinet) to 0 to 10V which, in turn, becomes the input signal to an electronic solid-state square root extractor. The square root extractor (also in the Probe Controls cabinet) converts the signal to a voltage signal linear with velocity.

The level sensing device in the probe ensures that the probe is always at a predetermined level of submersion in order to accurately measure the stream velocity at a reference level. It also detects the need for probe cleaning. An air bubbler arrangement is used for determining the level of probe submersion. This is done by sensing the bubbler backpressure. The bubbler outlet hole is located at the lower end of the probe adjacent to the target area of the velocity measuring device, in a position where it is not affected by the velocity of the flowing liquid. Should debris cause clogging, the probe has the capability of cleaning itself. This is accomplished by using the pneumatic cylinder

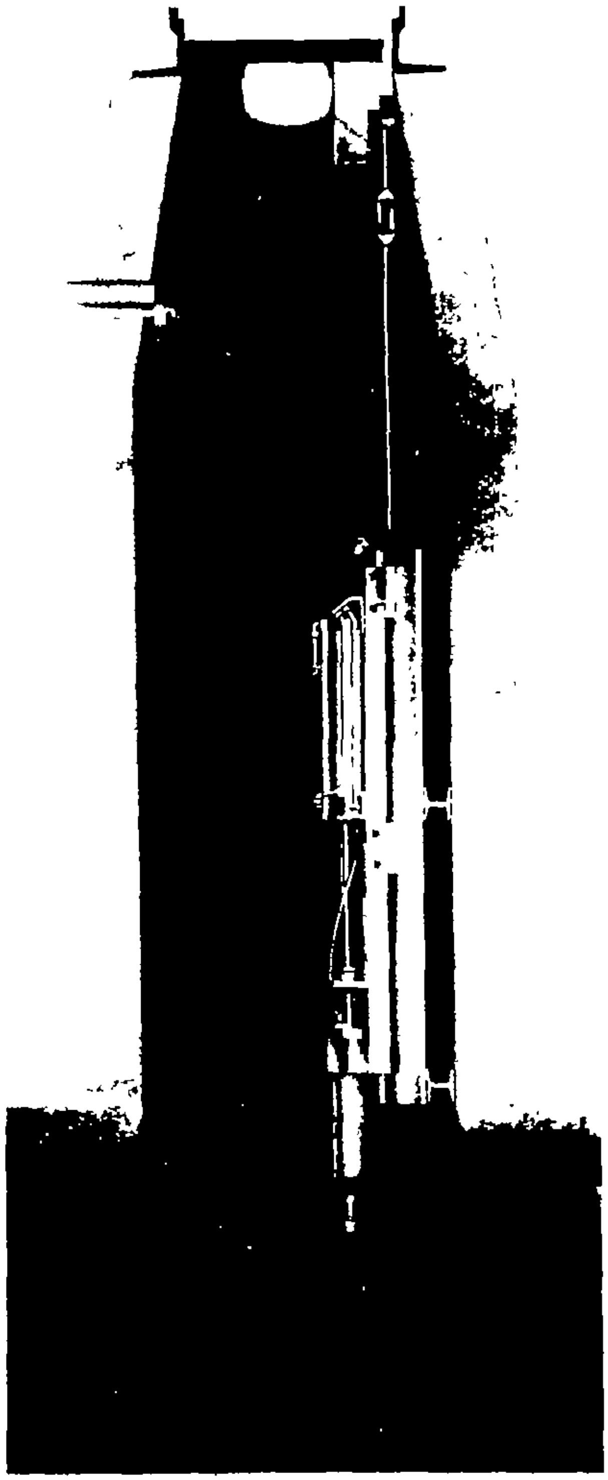


Figure A

to retract the probe through a tight-fitting wiper sleeve and then repositioning it. Simultaneously, a high-pressure air purge is directed at the velocity target area and also through the bubbler outlet hole. Normally the self-cleaning cycle is actuated at 15-minute intervals.

SPECIFICATIONS:

Size, Weight and Other Physical Facts:	Size and weight of the Monitor assembly can vary with the installation site requirements. A typical assembly for a 1.52m (5 ft) sewer conduit weighs approximately 136 kg (300 lbs.) and requires a trolley of 2.44m (8 ft) in length.
Power Requirements:	120V, 60 Hz, single phase, 30 ampere service.
Sewer Conduit Sizes:	1.22 to 6.1m (4 to 20 ft) (standard).
Liquid Level Ranges:	20.32 cm (8 in.) to full conduit
Velocity Measurement Range:	0 to 3 m/s (0 to 10 fps)
Air Supply:	Included in Probe Controls cabinet.
Sensitivity:	±0.64 cm (1/4 in.) change in liquid level.
Typical Accuracy:	Velocity, ±5% Level, ±0.64 cm (1/4 in.)
Repeatability:	No measurable changes in velocity and level over a period of one year.
Readout:	Analog-type panel meters included in Probe Controls cabinet.

OPTIONS

Installation Hardware:	As required.
Telemetry Output:	Two channels; one for velocity, one for liquid level. Either solid-state pulse duration or variable frequency may be considered. (Plug-in space is reserved

in the Probe Controls cabinet for either type of telemetry circuit boards, and for optional audio tone equipment.)

PRICE:

Prices are quoted at time of order based upon details of specifications-e.g. size, construction materials, etc.

COMMENTS:

Since this unit only provides the flow depth and velocity at about 15.2 cm (6 in.) below the free surface, calibration of the site would appear necessary in order to relate these two parameters to total discharge. The unit was not designed for smaller pipe sizes, i.e. under 1.22m (4 ft), and does not appear suitable for such applications.

MANUFACTURER: ASTRO DYNAMICS INC.
SECOND AVENUE
NORTHWEST INDUSTRIAL PARK
BURLINGTON, MASSACHUSETTS 01803
TELEPHONE (617) 272-3900

PRODUCT LINE: VOLUMETRIC FLOWMETERS

DESCRIPTION:

This company has developed a somewhat unique (patent pending) volumetric flowmeter. Its primary element essentially consists of a positive displacement (gear type) pump that is driven by a variable speed motor so as to maintain a zero pressure drop across the flowmeter. The secondary element is a counter that reads pump speed which is directly related to flow. A simplified block diagram of the unit is shown in Figure A.

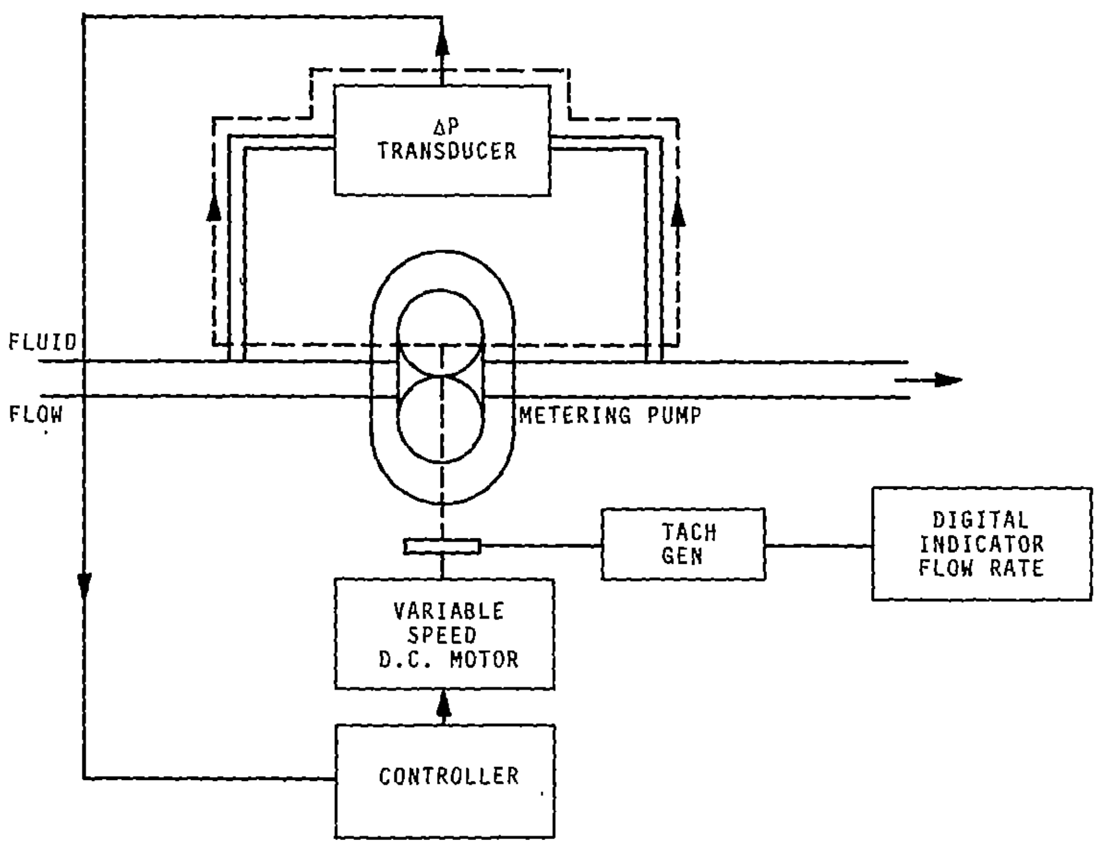


Figure A

The chief advantage of this approach would seem to arise from the fact that the slip factor, which is inherent in all such types of volumetric flowmeters, is greatly reduced with a nearly zero pressure differential. At the present time these flowmeters have only been built in rather small sizes, i.e., up to 577 ℓph (150 gph), but this is not an inherent limitation of the basic design. The unit was developed to meet a requirement for accuracies of ±0.2% of reading and repeatability of ±0.1% of reading; these have apparently been met. Ranges of up to 100:1 are possible, but 15:1 is more typical.

Units are available with either analog (0-10 VDC proportional to flow rates) or digital (pulse rate proportional to flow rate) outputs. Digital panel meters to read totalized flow (counter) or flow rate (digital voltmeter calibrated in gph) are optional at extra cost.

SPECIFICATIONS:

	Model		
Characteristics	LFM - 1.5 (A) or (D)	LFM - 15 (A) or (D)	LFM - 150 (A) or (D)
Range, lph (gph)	0.39-5.68 (0.1-1.5)	3.79-56.77 (1-15)	37.85-567.75 (10-150)
Power	115 VAC, 1Ø, 60 Hz	Same	Same
Dimensions (W,H,L), cm (in)	17.8x17.8x25.4 (7"x7"x10")	17.8x17.8x25.4 (7"x7"x10")	30x30x35 (12"x12"x14")
Tubing Connections, cm (in)	0.64 (1/4")	0.64 (1/4")	0.3 1 23 (1/2")
Max. System Temperature, C (F)	(150°F)	Same	Same

PRICE: $1,000 (approx.) and up.

COMMENTS:

This is a very ingenious device, but its application to wastewater flows must be considered limited due to its small capacity and potential problems with suspended solids, among other reasons.

MANUFACTURER: BADGER METER, INC.
INSTRUMENT DIVISION
4545 WEST BROWN DEER ROAD
MILWAUKEE, WISCONSIN 53223
TELEPHONE (414) 355-0400

PRODUCT LINE:

PRIMARY DEVICES - FLOW TUBES, NOZZLES, PARSHALL FLUMES

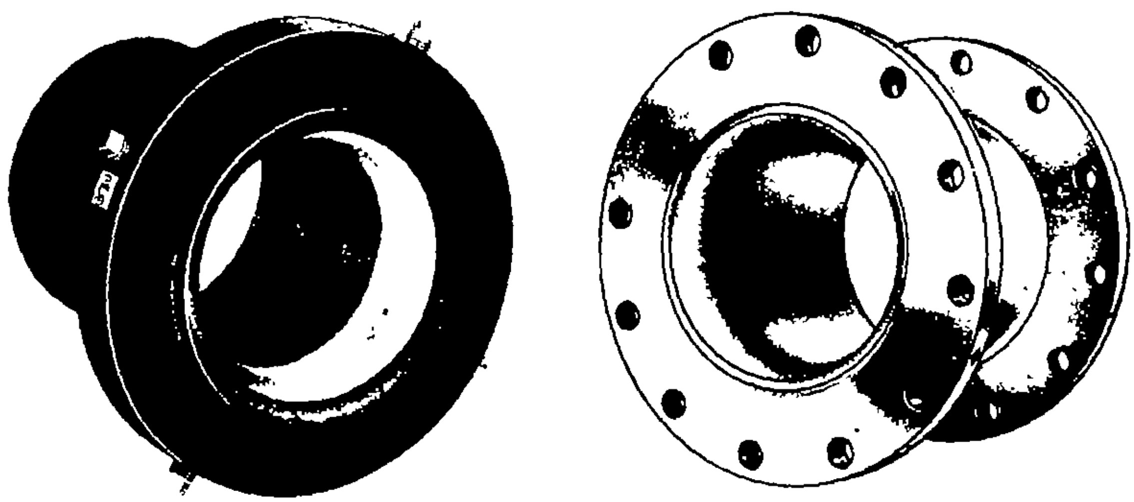
SECONDARY DEVICES - METER TRANSMITTER, ELECTRONIC RECEIVERS

DESCRIPTION:

The Water Meter Division of Badger has manufactured nutating disc type water meters for a number of years. However, because of the total unsuitability of such devices for raw sewage, they will not be included in this discussion.

Primary Devices

Flow Tubes - The Instrument Division offers, as primary elements, the proprietory "Lo-Loss" flow tubes. These tubes are available in a wide choice of designs, materials, and sizes and may find some application in wastewater flow measurement. Figure A shows typical "Lo-Loss" designs.



PLASTIC **CAST IRON**

Figure A

The chief advantage of the "Lo-Loss" design is its extremely low head loss (claimed to be the lowest of any primary element) even as compared to a long form Venturi tube. Unrecovered pressure loss as a percent of differential seldom exceeds 6%, and values of 3% are quite common. The available models include both full flanged and insert designs. Types PMT and PMT-U have manual vent cleaners for measuring sewage or slurries. Type PMT-S is a single-tap, full-flanged model design for sewage, sludge, or fluid high in suspended solids. Available designs are shown in Figure B.

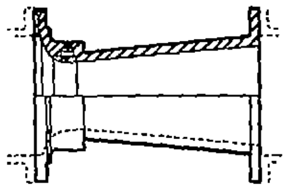
Open Flow Nozzles, Parshall Flumes - Badger Meter Inc. also offers open flow nozzles and Parshall flumes as primary devices.

Secondary Devices

Transmitter - The ML-MN transmitter (Figure C) is a secondary device designed for open channel flow head measurement. As flow varies, the transmitter's in-stream float senses the changing liquid level in the primary flow device. Through a single link from a stainless steel main shaft, the float's motion is relayed directly to core which moves vertically within the transmitting coil. The coil emits a signal voltage in direct relation to the core position. This signal is transmitted to the electronic receiver as discussed in the description of the electronic receiver.

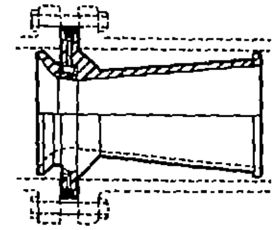
Advantages of this device, when compared to float-cable instruments which require stilling wells, are reported to be as the following:

- INSTALLATION ECONOMY...Excavation and concrete pouring for meter chambers are minimized. Stilling well and complex piping eliminated.
- MAINTENANCE ECONOMY..Clear water purge, routine cleanouts, cables, and counter weights also eliminated.
- ACCURACY CHECK...A mechanical position reference is furnished as standard equipment to provide a quick, positive calibration check.
- APPLICATION VERSATILITY...ML-MN transmitter and electronic receiver can be used with Badger Meter open flow nozzles, Parshall flumes, and weirs. Accurate response is also assured with Palmer-Bowlus flumes, standing wave flumes, and any other device for which the head-discharge relationship has been established up to a float travel of 0.8m (32 in.).



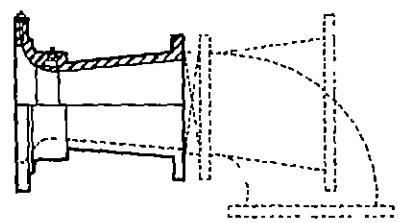
TYPE PMT: FULL FLANGED CAST IRON

This cast iron tube has a bronze-lined throat in which the averaging annulus is accurately machined with the body. Stainless steel throat also available. Manual vent cleaners provided for sewage, slurries or other fluids with suspended solids



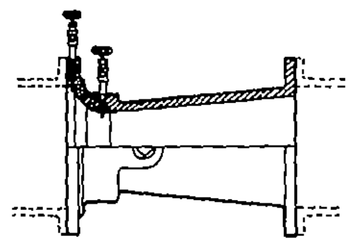
TYPE PMT-I: PLASTIC INSERT

The polyester-fibreglass body, tapped holding flange, and throat with internal annulus are molded as an integral unit. Throat and mounting flange are available in a variety of materials Suitable for liquids and gases up to 200° F Minimum operating temperature minus 20° F.



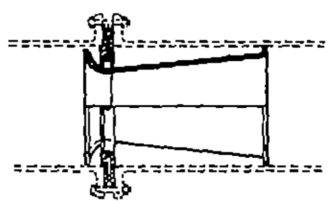
TYPE PMT-C: "CONTROLLER" TUBE

This model is similar to Type PMT except that it will accommodate a valve immediately downstream for rate-of-flow control. Outlet flange may be smaller than line size to permit a smaller valve. A standard increasing elbow or increaser is used to return to full line size



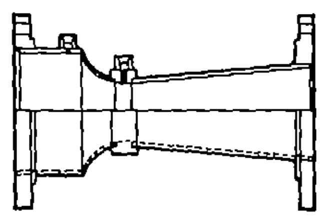
TYPE PMT-S: SINGLE TAP, FULL FLANGED

Designed for sewage, sludge or fluids with suspended solids. This tube has single taps for the high pressure and for the low pressure connections Each tap is equipped with manual vent cleaner to permit periodic cleaning.



TYPE PMT-IF: FABRICATED INSERT

Designed primarily for clear fluids, Type PMT-IF is available in a variety of materials to suit specific applications. Can be supplied in carbon or stainless steel, aluminum, chrome-moly and other metals. Pressure connections are conveniently located in mounting flange.



TYPE PMT-U: FABRICATED FULL FLANGED

This Lo-Loss tube offers wide flexibility in materials and design. An economical buy, particularly in the larger sizes. Can be supplied with single or multiple taps. Also available with manual vent cleaners for measuring sewage or slurries.

Figure B

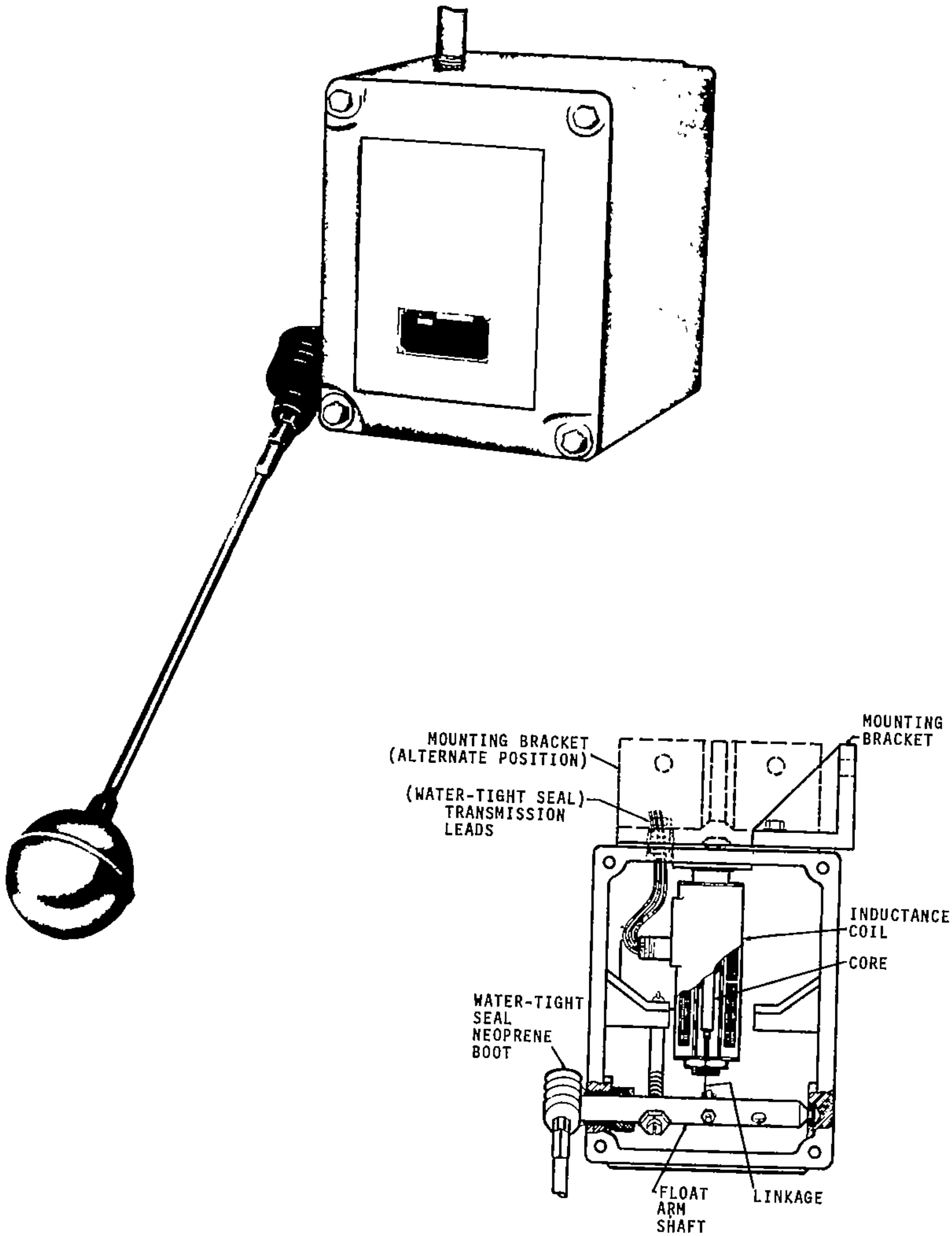

MOUNTING BRACKET
(ALTERNATE POSITION)
(WATER-TIGHT SEAL)
TRANSMISSION
LEADS
MOUNTING
BRACKET
INDUCTANCE
COIL
CORE
WATER-TIGHT
SEAL
NEOPRENE
BOOT
FLOAT
ARM
SHAFT
LINKAGE

Figure C

Electronic Receiver - The Badger Meter Inc. 2700 Series electronic receiver (Figure D) is connected to the transmitter (Figure C) by three transmission lines (Figure E), and power (110 VAC, 60 Hz) is applied only to the receiver. An actuating signal or error voltage is produced by the movement of the transmitting core within its coil which unbalances the electrical bridge. This signal is amplified to drive a two-phase, reversible servo motor which runs at a speed proportional to the error signal and in a direction established by the phase. Rotation of the motor repositions the core in the receiving coil and reduces the error signal to zero. As a result, the electrical bridge is restored to a null-balance condition. The pen, indicator pointer, and totalizer mechanisms are positioned simultaneously when the system is in balance; thus there is no time delay for recycling.

Receiver Style 2701 serves the combined functions of a recording, indicating, and totalizing instrument; Style 2705 is used as a remote indicator only.

As reported by Badger Meter Inc., the 2700 series electronic receiver can be used with a variety of transmitters for the measurement of flow, level, pressure, or temperature. For the convenience of the operator, the receiver can be located up to 5000 feet away from the transmitter without impairing calibrated accuracy (±1% of actual value being measured over the range specified for the transmitter) or speed of response. A selection of 30.5 cm (12 in.) diameter charts, with either 24-hour or 7-day rotation, can be made from more than 500 standards available.

SPECIFICATIONS:

Primary Devices

- The laying length of a typical "Lo-Loss" flow tube is roughly 2.5 times the pipe diameter. Stock units are available for pipe diameters ranging from 7.6 to 121.9 cm (3 to 48 in.), and other sizes can be obtained upon request.

- Bronze, carbon or stainless steel, aluminum, chrome-moly, and polyester-fiberglass are among the available construction materials.

- Standard accuracies of ±1% are claimed (or ±0.25% when laboratory calibrated).

- Ranges (see comparative rangeability of Figure F) of 20:1 are common, and even at 50:1, the meter coefficient deviation is only 2%.

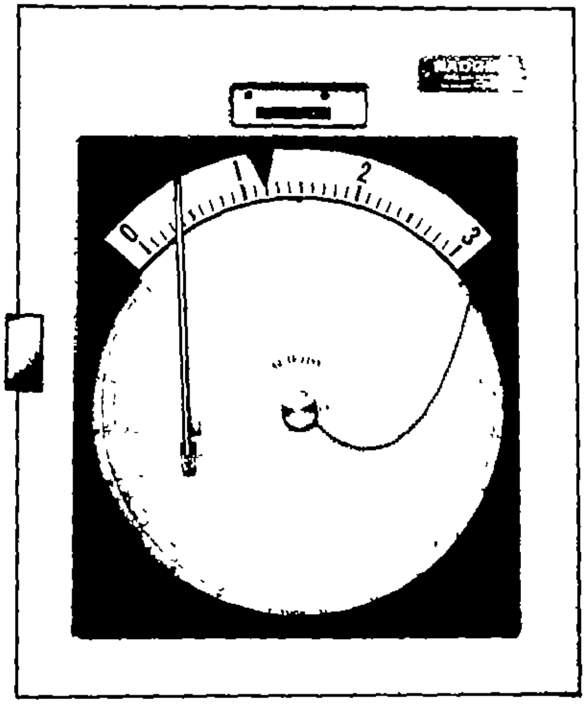


Figure D

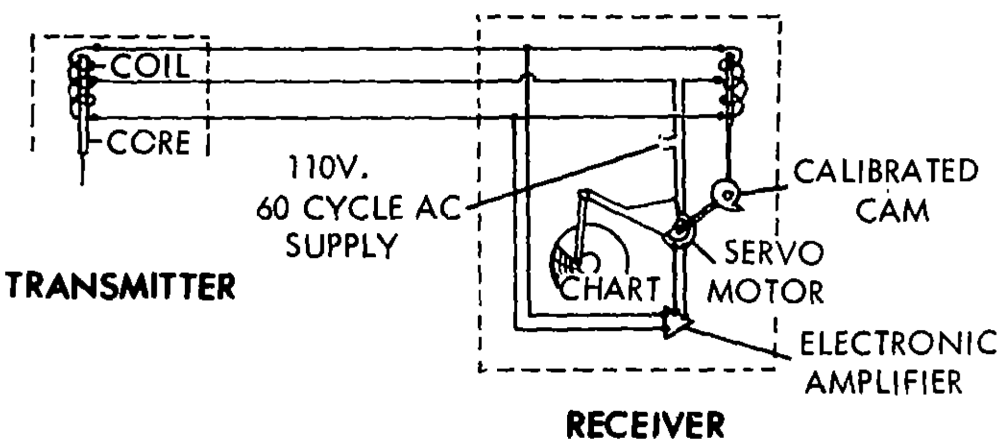


Figure E

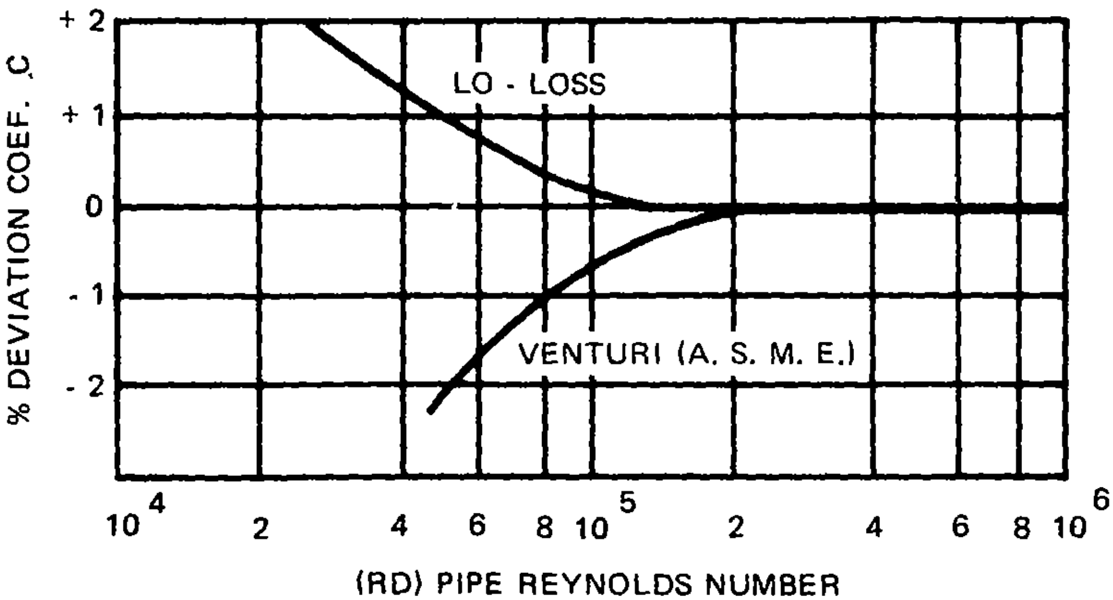


Figure F

Secondary Devices

	ML-MN Transmitter	2700 Series Receiver
Range	10:1 (20:1 available for extra cost)	N/A
Dimensions, (W, H, L)	25.8cm x 25.4cm x 32.4cm (10-3/16in x 10in x 12-11/16in)	22.2cm x 39.1cm x 48.9cm (8-13/16in x 15-5/8in x 19-3/16in)
Power	N/A	110 VAC, 60 Hz
Response Time	N/A	8 sec. (0 to Full Scale)

PRICE:

Primary Devices

"Lo-Loss" Flow Tubes	3 in.	-	$ 716.00
	48 in.	-	11,700.00

Open Flow Nozzles	6 in.	-	$ 640.00
	24 in.	-	3,900.00
Parshall Flumes	3 in.	-	280.00
	24 in.	-	1,565.00

Secondary Devices

ML-MN Transmitter/2700 Series Electronic Receiver $ 1,150.00

COMMENTS:

Primary Devices

Where pressurized flow is always present, the "Lo-Loss" flow tube could prove to be a useful primary device for measuring storm or combined sewer flows at fixed installations, if proper attention is paid to the secondary element to avoid clogging problems.

The other primary devices offered by Badger (open flow nozzles and Parshall flumes) were thoroughly discussed in Section VI and will not be commented upon further here.

Secondary Devices

The ML-MN transmitter will withstand submergence, even though it will no longer operate because the float is off scale. Its 0.8-meter (32-inch) float travel allows it to be used with many primary devices. As with any float-in-flow secondary device, it suffers from the possibility of fouling (or even physical damage) from floating debris. The electronic sensing system offers advantages over more cumbersome cable and counterweight designs.

MANUFACTURER: BADGER METER, INC.
PRECISION PRODUCTS DIVISION
6116 EAST 15TH STREET
TULSA, OKLAHOMA 74115
TELEPHONE (918) 836-4631

PRODUCT LINE: ULTRASONIC FLOWMETER;
ULTRASONIC TRANSMITTER

DESCRIPTION:

Badger Meter, Inc. has entered into a cooperative agreement with Tokyo Keiki Seizosho Company, LTD. of Japan to market (within the United States) the ultrasonic flowmeter developed by the latter company. There are essentially three devices offered, and sales are through the Precision Products Division. A typical ultrasonic meter installation for full pipe flow is shown in Figure A.

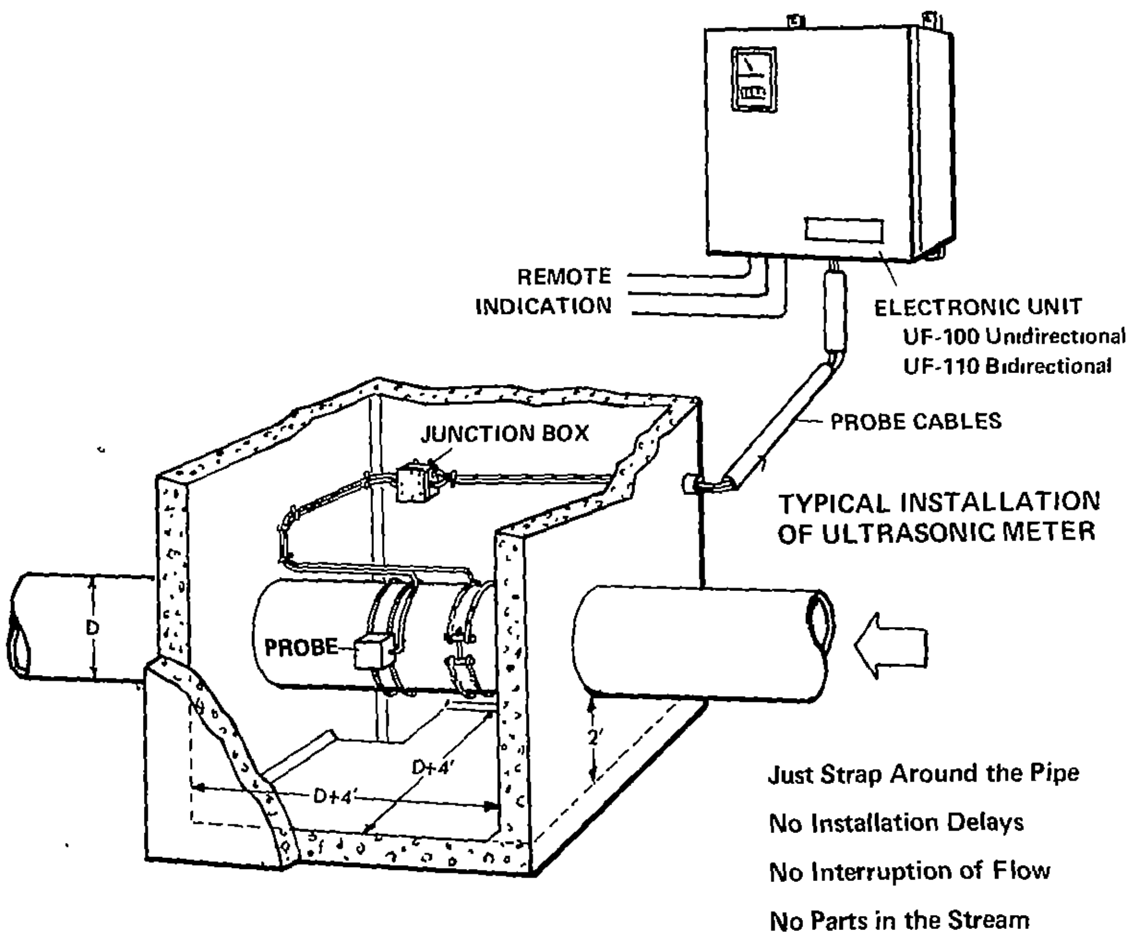


Figure A

The ultrasonic flowmeter uses the propagation of ultrasonic energy across a fluid stream to determine flow velocity. These devices are designed for metering raw and treated sewage and wastewaters; also, many industrial fluids can be metered.

Model UF-100 (Unidirectional) and UF-110 (Bidirectional) Flowmeters - These are complete ultrasonic flowmeters for measuring full flow in pipe sizes of 0.3m (1 ft) and larger. These devices employ a pair of ultrasonic velocity probes that are strapped to the outside of the pipe wall. A clearance area measuring at least 1.2m (4 ft) greater than the pipe diameter in each dimension is required. The device can be installed in existing as well as new construction and produces no head loss since there is nothing inside the pipeline. The velocity probes utilize the "sing-around" principle* to measure average fluid velocity within the pipe which is combined with pipe cross-sectional area to produce an output signal (4-20 mADC) proportional to flow. A wide selection of 30.5 cm (12 in.) diameter charts is available with either 24-hour or 7-day rotation. A totalizer option is also available.

Model UF 310A Flowmeter - This model is a complete open channel ultrasonic flowmeter that does not require the use of a weir, flume, or other pre-rated structure. It employs a pair of ultrasonic velocity probes and combines their output with flow depth as measured by an ultrasonic depth probe (essentially the probe of Model UH 200) and channel cross-section to produce an output signal (4-20 mADC) proportional to flow. The device can be installed in existing as well as new construction and will produce little or no head loss since, at most, only the small velocity probes need be in the flow. As with the Models UF-100 and UF-110, the velocity probes operate using the "sing-around" principle. Channel shapes can be either circular, rectangular, trapezoidal, or elliptical. As shown in Figure B, the velocity probes are generally mounted in, or attached to, the channel walls at about 25% of maximum depth. A wide selection of charts (identical to those for Models UF-100/110) is available, as is a totalizer option and bidirectional capability. The three probes, which together weigh 38.6 kg (85 lbs), may be located up to 305m (1000 ft) from the electronics box, which is a small wall-mounted unit weighing 68 kg (150 lbs).

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* Each received sonic pulse triggers the transmission of another pulse across the flow stream in a "sing-around" fashion. The number of such pulses occurring in a one-second period is called the sing-around frequency.

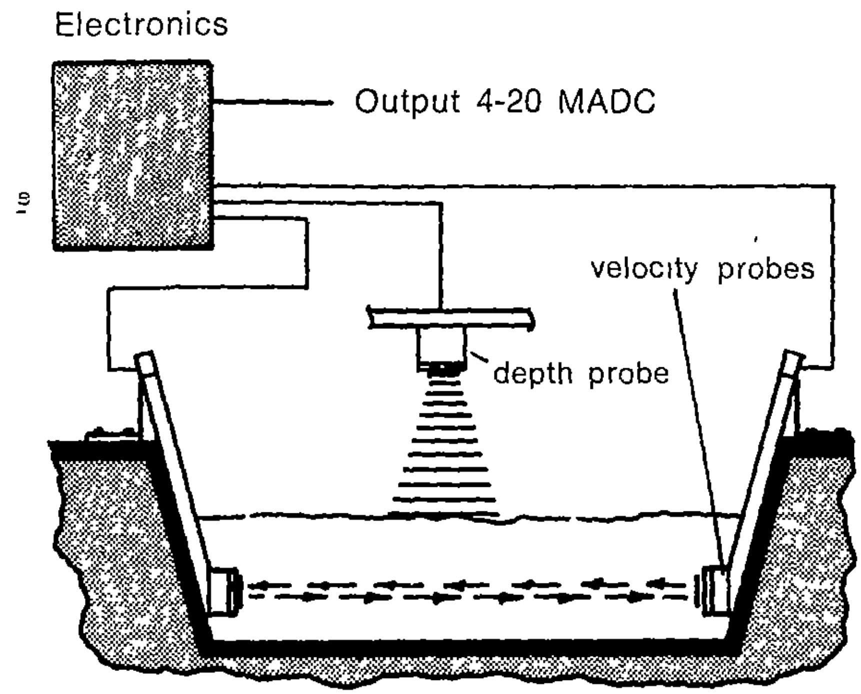
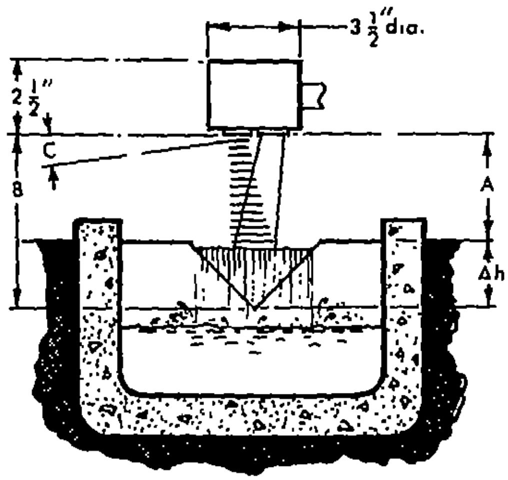


Figure B

Model UH 200 or UH 210 Ultrasonic Flow Transmitter - This equipment has an output signal proportional to level (UH 200) or flow (UH 210) and serves as a secondary element for level and flow indicating, recording, and totalizing measurements in flumes, weirs, or other open channel primary elements. The device employs an ultrasonic probe set in a common head. The acoustic signal is transmitted to the fluid surface (see Figure C), and the elapsed travel time for the reflected signals' return is converted into fluid depth. As the level of the fluid



INSTALLATION

A Transmitter shall be placed at least 6" above maximum level not to exceed the Δh above maximum level (i e. Δh min. = 6")

B Total transmission length shall not exceed 10' 6"

C. The horizontal plane across the face of the probe shall be level to within ± 2°

Figure C

surfaces changes, the UH 200 produces a proportional signal (4-20 mADC). Model UH 210 incorporates a digital function generator which allows direct and continuous conversion of the fluid level signal to any specified depth-discharge relationship. This can be changed in the field to allow use with different primary elements. A wide variety of 30.5 cm (12 in.) diameter charts is available with either 24-hour or 7-day rotation.

SPECIFICATIONS:

Characteristic	Model		
	UF-100 and 110	UH-200 and 210	UF-310A
Resolution	±1% of Full Scale	±1/4% of Full Scale	±1% of Full Scale
Accuracy	±1% of Full Scale	±2% of Full Scale	±3% of Full Scale
Output			
Analog	4-20 mADC into 1000Ω	Same	Same
Time Pulse	3-9-3 (15 sec. period)	N/A	N/A
Digital	48V Pulse (Train Scaled)	N/A	N/A
Probe Cable Length	Up to 305 meters (1000 ft)	Same	Same
Power	115 VAC, 60 Hz, 3A	Same	Same
Dimensions			
Electronics	57 x 64 x 30 cm (22.44x25.20x11.81 in)	22.7 x 13.7 x 34.3 cm (10-1/2x5-3/8x13-1/2 in)	
Junction Box	8.4 x 18 x 20 cm (3.3x7.1x7.9 in)	N/A	N/A
Probe(s)	12.4 x 15.0 x 18.3 cm) (4.9x5.9x7.2 in)	8.9 cm (3.5 in) Dia. X 6.4 cm (2.5 in) High	
Weight			
Electronics	54 kg (119 lbs)	7.3 kg (16 lbs)	
Junction Box	2.5 kg (6 lbs)	N/A	N/A
Probe	16.8 kg (37 lbs)(2)	1.8 kg (4 lbs)(1)	38.6 kg (85 lbs)(3)

PRICE: Models UF-100 and UH-110 start at about $1,000

Model UF-310A starts at about $3,000

Models UH 200 and UH-210 start at about $3,000

COMMENTS:

These ultrasonic flow measurement devices have performed fairly well in their somewhat limited (up until now) use in this country. Models UF-310A and the UH series are especially well suited for storm and combined sewer flow measurement. There have been some reports of problems due to echos or false returns from the UH series probes. Some field workers have put a short piece of plastic pipe over the head and obtained improved results.

MANUFACTURER: BIF - A UNIT OF GENERAL SIGNAL
1600 DIVISION ROAD
WEST WARWICK, R.I. 02893
TELEPHONE (401) 885-1000

PRODUCT LINE:

PRIMARY DEVICES - PARSHALL FLUME LINERS, VENTURI TUBES AND NOZZLES, DALL FLOW TUBES, KENNISON OPEN FLOW NOZZLES

SECONDARY DEVICES - "CHRONOFLO" TRANSMITTER AND RECEIVER UNITS, PRESSURE SENSORS, TOTALIZERS, AND INDICATORS

DESCRIPTION:

BIF, a unit of General Signal Corporation, has been active in the water flow measuring field for over 100 years. Their primary flow measuring products include such devices as Parshall flume liners, the recently developed Universal venturi tube which has largely replaced their Dall flow tubes, and Kennison open flow nozzles. BIF also offers the Solids Bearing Fluids (SBF) Flowmetering System, which is reported to provide precise, highly sensitive detection of differential pressures created by Universal Venturi Tubes when the measured fluid is high in suspended solids.

BIF's secondary units are represented by several Chronoflo transmitter and receiver units for indicating flow depths in primary devices.

Parshall Flume Liners - BIF's precision-molded, one-piece plastic Parshall flume liner, Model 141, is said to accurately duplicate Parshall flume proportions. It is light-weight and can be easily installed without the aid of a crane or special tools; there are also no seams requiring special cements or sealing compounds. BIF plastic Parshall flume liner Model 141 is available in throat width sizes ranging from 7.62 cm (3 in.) to 2.44m (8 ft) to accommodate flow rates ranging from 75.7 kld (.02 mgd) to 341,255 kld (90.16 mgd). Parshall flumes were throughly treated in Section VI and will not be discussed further here.

Universal Venturi Tube - BIF has developed a proprietary, differential-pressure primary device that combines the metering performance of the classical venturi tube with some of the more desirable features of differential pressure devices such as the Dall flow tube. It offers extremely short laying lengths (less than half that of a short form classical venturi tube), a great magnification of the differential pressure signal (about twice that of classical venturis), and low permanent head loss (almost as little as a Dall tube). The advantages offered by the Universal Venturi Tube are due to its unique hydraulic design, especially from the inlet to the throat tap (see Figure A), that "conditions" the flow by creating a consistent artificial turbulence in the throat flow pattern so that readings are stable and predictable. No blending radii are used, so flow separation and stream-line bending are employed as in the Dall tube.

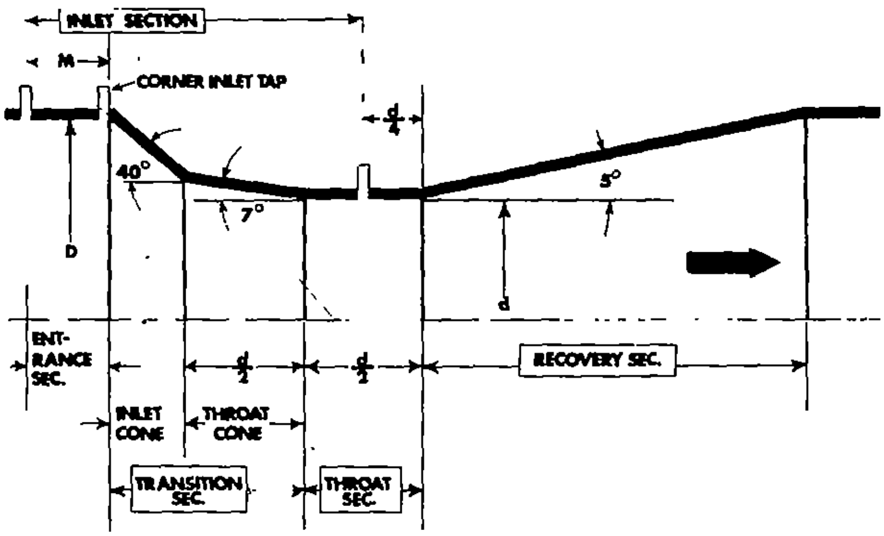


Figure A

The Universal Venturi Tube is available in line sizes from 2.5cm (1 in.) to 1.2m (4 ft) as stock and up to 2.4m (8 ft) on special order. Even larger units can be made on request. Series 180 Universal Venturi Tubes are available as insert types or flanged types. Standard tubes have cast iron bodies and bronze throats with the cast iron surfaces (both interior and exterior) finished with tar or Bitumastic paint. A large variety of other materials are available in weldment form, and fiberglass reinforced plastic insert types are also standard construction.

The tube coefficient is virtually independent of the Beta ratio (ratio between throat and inlet diameters), the pipe Reynolds number (above about 50,000), and line sizes. There is virtually no installation effect caused by upstream piping configurations, and downstream piping causes no effect whatsoever. As a result, uncalibrated accuracies of ±0.75% can be guaranteed and, with calibration, ±0.25% is achievable. Standard ranges are around 5:1.

<u>Kennison Open Flow Nozzle</u> - This open flow nozzle is a simple device for measuring flows through partially filled pipes. The nozzle handles low flow and wide flow ranges with ease. Because of its high accuracy, non-clogging design and excellent head versus flow characteristics, the Kennison nozzle is well suited for the measurement of raw sewage, raw

and digested sludge, final effluent, and trade wastes. The Kennison Nozzle is constructed of high tensile cast iron. The piezometer vent opening is bushed in brass and is equipped with a bronze-mounted manual vent cleaner. Hydraulically-operated vent cleaning can also be used where the nozzle is installed in inaccessible places. The nozzle is available in inlet diameters of 15.2 to 91.4 cm (6 to 36 in.) and will accommodate flows of 340 to 53,000 ℓpm (90 to 14,000 gpm).

Uncalibrated accuracies of ±2% for a range of 10:1, ±3% for a range of 15:1, and ±5% for a range of 20:1 have been demonstrated. Special laboratory calibration will assure accuracy within ±1% of actual flow for a range of 20:1. A Kenniflo rate indicator is available for use with the nozzle to provide visual evidence of instantaneous rate of flow. This indicator can be graduated in gpd, gpm, or mgd as well as inches of head.

Solids Bearing Fluid Flowmetering System (SBF) - As shown in Figure B, the SBF system is built around a combination of components -- the primary element, a Universal Venturi Tube Model 185 (UVT) (center); two pressure sensing probes (upper right); and a differential pressure transmitter (lower left). All of these components may be purchased individually. Claims made for this system include:

- No electrical components are in contact with line fluid.
- Water purging is eliminated.
- No circuit fouling or drift occurs.
- Instrumentation lines cannot be fouled by solids or entrained gases.
- System is unaffected by changes in static line pressure.
- Sensors can be removed while line is in service.
- System provides highly sensitive detection of flow signals produced by the venturi tube.
- All readings can be verified by a simple manometer.

The above is accomplished by the direct one-to-one transfer of pressure through a limp diaphragm which is held at a precise null position, regardless of the magnitude of the measured pressure, by a pure silicon fluid pressurized by a miniature hydraulic gear pump. The liquid is delivered continuously through a filter to the probes at a pressure consistent with line pressure, and exhaust fluid is fed back to the

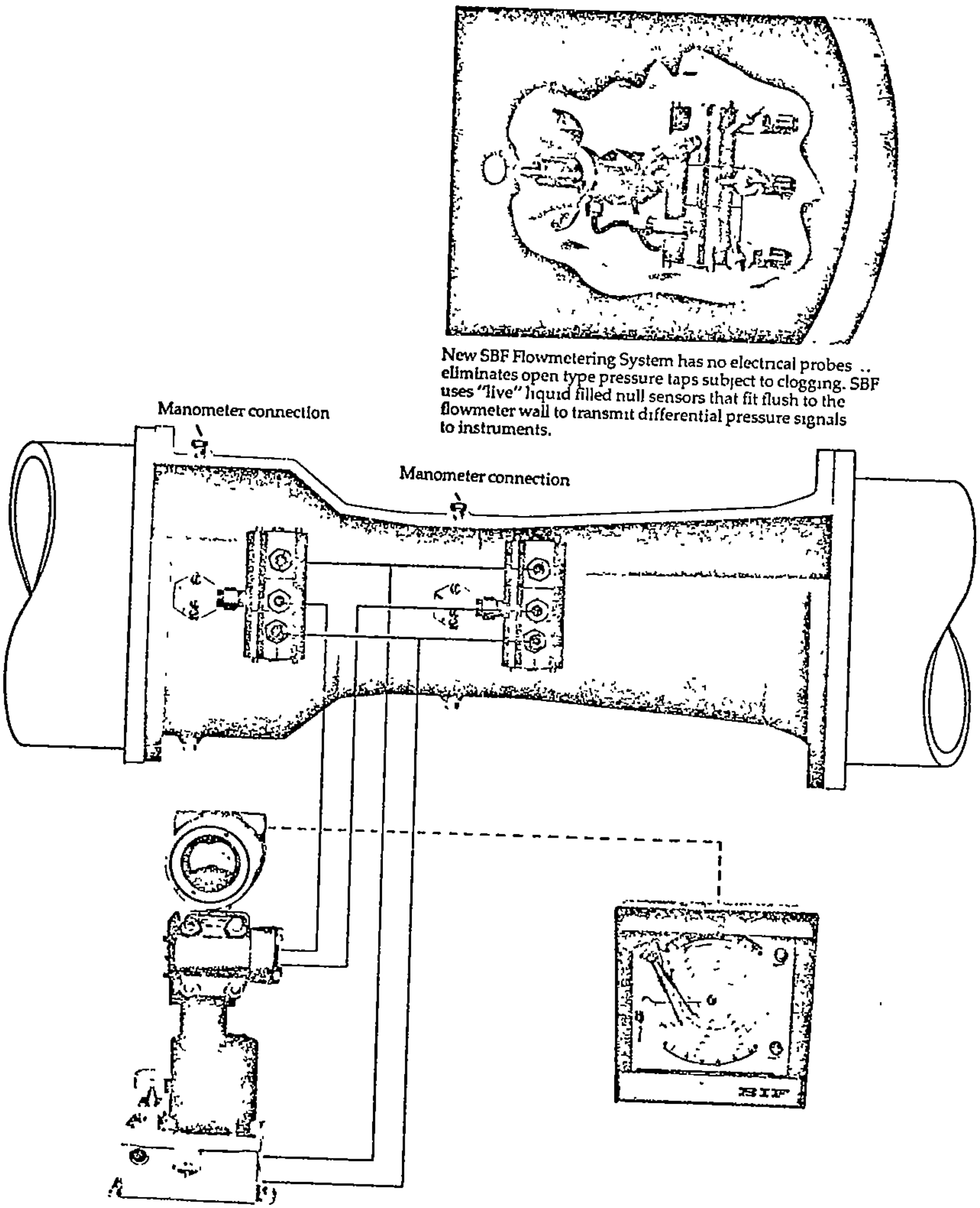

New SBF Flowmetering System has no electrical probes .. eliminates open type pressure taps subject to clogging. SBF uses "live" liquid filled null sensors that fit flush to the flowmeter wall to transmit differential pressure signals to instruments.
Manometer connection
Manometer connection
BIF

Figure B

pump reservoir. Due to the reset action provided by the supply-exhaust regulator unit associated with each probe, sensing diaphragm movement is limited to less than 0.03 mm (0.001 in.). The center button of the diaphragm carries one end of an armature, the other end of which is supported and centered by a spiral-spring bearing. The end of the armature acts as a baffle and floats close to the nozzle, regulating exhaust of the fluid from the probe to the exhaust pressure regulator. This probe system is highly responsive to rapid pressure changes, essentially behaving like a filled-and-sealed system.

Transmitter Units - BIF manufactures several secondary transmitter units. The Model 231-08 is a float actuated, free-standing, weatherproof Chronoflo transmitter-indicator mounted in a waterproof stand for level indication at its location. It also transmits readings to Chronoflo receivers for remote indicating and recording. The remote signal line requirements can be met by leased signal facilities equivalent to low frequency telegraph channel capable of repeating time-duration impulse closures or a private metallic pair with a maximum loop resistance not to exceed 2500 ohms.

The BIF Chronoflo Model 231-09, used for flow rate determination, is identical to the Model 231-08 in appearance, weight, and signal line and power requirements. Both are designed for stilling well operation.

The BIF Chronoflo Model 231-34 is an in-stream, float-operated electrical transmitter designed especially for use with head-area primary flow measuring elements such as Parshall flumes, Kennison nozzles, weirs, and other open flow primary devices. This transmitter operates with equal facility over telephone or teletype lines, telegraph circuits, private signal lines, tone or microwave links. The unit consists of the transmitter, indicator (optional extra), a spherical, truncated float manufactured of ABS plastic, and a nylon-coated, stainless steel float cable.

The Model 251-08 electronic differential pressure transmitter is a compact transducer designed to translate a differential pressure into a DC current signal and is designed to work with the SBF flow metering tubes only.

Miscellaneous - BIF also manufactures a line of pressure sensors and Chronoflo receivers, recorders, and summator/subtractor totalizer units for use with the primary and secondary units described above.

The SBF system's recording device is BIF's electronic receiver and is available in either strip or round chart, compact or full case models. The electronic receiver will accept both 4-20 mA and 1-5 volt signals.

SPECIFICATIONS:

Typical specifications for the BIF line of secondary flowmetering devices are as follows:

Model 231-08 Transmitter

Accuracy:	±0.5% for a range of 100:1
Dimensions:	143.5 cm (56-1/2 in.) height with a base dimension of 48-1/4 by 31 cm (19 x 12-1/4 in.).
Weight:	136 kg (300 lb).
Power:	115 VAC, 60 Hz @ 6 watts

Model 231-09 Transmitter

Standard Accuracy:	±0.5% of maximum rate.
Extended Accuracy:	±1% of actual reading.
Range:	10:1 for a maximum float travel of 12.7 cm (5 in.) to 30.48 cm (12 in.).
	20:1 for maximum float travel of 30.48 cm (12 in.) to 76.2 cm (30 in.).

Model 231-34 Transmitter

Standard/Extended Accuracy:	±2%/0.5% of maximum instrument reading.
Range:	10:1 for maximum float travels from 12.7 to 30.5 cm (5 to 12 in.);
	20:1 for maximum float travels over 30.5 cm (12 in.), except on applications with Parshall flumes or Kennison nozzles where head at maximum rate is less than 2.54 cm (1 in.) for maximum float travels up to 45.7 cm (18 in.), or 3.81 cm (1.5 in.) for maximum float travels over 45.7 cm (18 in.).
Dimensions:	Float - 15.24 cm (6 in.) dia.
	Float Cable - 0.09 cm (0.035 in.) dia.

Power: 115 VAC, 60 Hz, Single Phase

PRICES:

Standard prices not available at the time of this writing.

COMMENTS:

Parshall flumes and Kennison open flow nozzles were discussed fully in Section VI and will not be commented upon further here. The Universal Venturi Tube would appear to be one of the better differential-pressure type primary devices for use with sewage. Its requirements for full pipe flow and small range (5:1) may limit its application, however. The pressure probes used in the SBS would seem useful for other differential-pressure devices and can be purchased separately. They could be used with existing differential pressure devices where line plugging or other problems have been high and maintenance troublesome.

MANUFACTURER: BRAINCON CORPORATION
A COMPANY OF TALLEY INDUSTRIES, INC.
MARION, MASSACHUSETTS 02738
TELEPHONE (617) 748-1085

PRODUCT LINE: CURRENT METERS

DESCRIPTION:

The Braincon Corporation produces two basic types of primary current meters. The type 381 and 1381 Histogram current meters utilize 2/3 and full size Savonius rotors, respectively, and record current rates on 16 mm film by taking time exposures of radio-luminous sensor indicators. Braincon maintains complete processing and data translation facilities. These current meters will not be discussed further since application in the measurement of wastewater flow rates is inappropriate.

Braincon has developed a Model 720 electromagnetic current meter that is capable of monitoring flows between 0 to 2 m/s (6.6 fps). It uses an orthogonal array of four electrodes in the sensor head to present instantaneous readings of the N-S, E-W components of the flow. The output voltage varies linearly with the velocity of the fluid flow over the sensor head. The Model 720 meter utilizes an oblate ellipsoidal form (discus) probe that efficiently preserves laminar flow over a generous range of adverse conditions. Of interest is its superior performance improvement over historically accepted mechanical transducers such as the Savonius rotor. Also noteworthy are the total freedom from any mechanical designs; the use of a solid state fluxgate magnetometer rather than a conventional compass; its high resistance to fouling; lower meaningful measuring thresholds; the use of Cartesian coordinates rather than polar; instantaneous readout of N-S, E-W vector components; high sensitivity to the physical environment; a faithful cosine response; and less application dependency in critical wave-zone effect areas.

The 720 current meter can be used with a variety of readout devices if the proper interface is provided. Lengths of electrical cable up to approximately 30m (100 ft) are provided as standard equipment with the Model 720, with additional lengths available.

SPECIFICATIONS:

Output:	±2 VDC full scale (other ranges available)
Accuracy:	±1.5 cm (0.6 in.)/sec or 2% of full scale
Threshold:	< 2 cm (0.78 in.)/sec

Resolution:	0.5 cm (0.2 in.)/sec
Power:	24 ± 4 VDC
Operating Temperature:	-2°C (28°F) to 40°C (104°F)
Length:	107.6 cm (42.35 in.)
Diameter:	20.3 cm (8 in.), maximum
Weight:	23 kg (50 lb)

PRICE: Standard surface readout model: $5,000

Deep-water, long-term implant model: $8,000

COMMENTS:

This electromagnetic current meter was designed for oceanographic applications, but may find some use as a portable current meter for attended operation in measuring wastewater flows. Its low upper velocity limit will severely restrict its use, however.

MANUFACTURER: BROOKS INSTRUMENT DIVISION
EMERSON ELECTRIC COMPANY
407 WEST VINE STREET
HATFIELD, PENNSYLVANIA 19440
TELEPHONE (215) 247-2366

PRODUCT LINE: VARIABLE-AREA FLOWMETERS, TURBINE FLOWMETERS, POSITIVE DISPLACEMENT FLOWMETERS PROPELLER METERS, LIQUID LEVEL INSTRUMENTS, ELECTROMAGNETIC FLOWMETERS, ETC.

DESCRIPTION:

Brooks manufactures a complete line of glass and metal metering tube variable-area flowmeters (rotameters) in sizes to 12,000 ℓ/m (3,200 gpm) and priced from $50 to $6,000. A number of pneumatic or electric transmitters, receivers, alarms, etc., are available as accessories. None of these is considered suitable for wastewater flow measurement and, consequently, no further discussion of them will be given.

Primary Devices

Brooks turbine flowmeters are manufactured in six different series for use in various types of service, including chemical, cryogenic, aircraft fueling, and petroleum pipelines, etc. Ranges of 10:1 are standard, and accuracies as great as ±0.15% (with repeatability within 0.015%) are available with the Series M viscosity-compensated turbine meters. Prices range from $340 to $13,800. Brooks also offers a complete line of accessories including indicators, totalizers, printers, etc.

Brooks manufactures nutating disc, oval gear, oscillating piston, and bi-rotor type positive displacement meters in various models and sizes, all of which are designed for clean fluid service only. The same is true of their bulk water propeller meters. Since their application to wastewater flows is not recommended, they will not be described further.

The Series 7100-7200 electromagnetic flow transmitters manufactured by Brooks are solid state flow rate sensing elements. A typical unit is depicted in Figure A. They are designed to withstand tough service applications such as corrosive, humid and dirty environmental conditions, wide variations in temperatures, and high vibration loads. All adjustments are precise and are made externally; once set, there is no change. The three-electrode design is immune to changes in conductivity of the metered liquid. The transmitter utilizes an integral FET type preamplifier (impedance converter) to provide a low impedance output signal to permit long lengths of interconnecting cables without

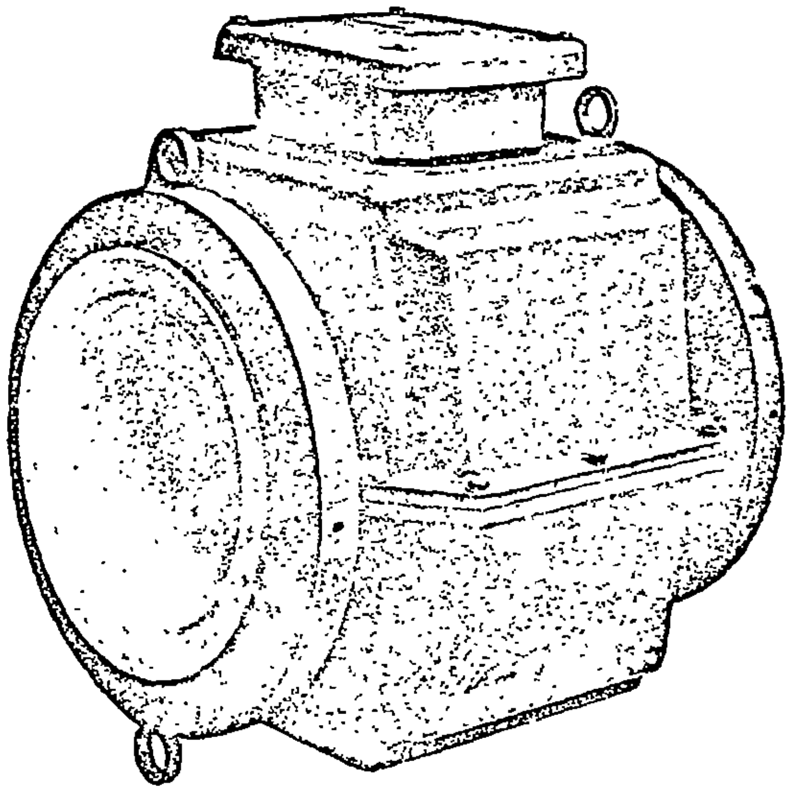


Figure A

regard to liquid conductivity or adverse effects of noise pickup. Brooks-Mag transmitters, in conjunction with Brooks-Mag signal converters, provide output signals which are compatible with almost any manufacturer's secondary equipment. Electromagnetic transmitters and signal converters are fully interchangeable and are adjusted and calibrated independently of each other. The transmitter uses a potentiometer to adjust a reference voltage whose ratio to the signal voltage is constant in all transmitters regardless of size, materials of construction, and liquid being metered. Signal converters are always adjusted to identical input values.

Standard meter sizes are from 0.25 cm (0.1 in.) to 1.2m (4 ft), and units up to 2.4m (8 ft) are available on special order. Normal velocity ranges are 0 to 9 m/s (30 fps), and standard accuracy is ±0.5% of full scale over the entire flow range. The design features a short laying length; e.g., a 61-cm (24-in.) diameter meter is only 76 cm (30 in.) long. Type 304 stainless steel is the standard metering tube material, and various line materials such as neoprene, gum rubber, polyurethane, etc., are available. Among the units other design features are:

- LOW POWER CONSUMPTION - yet has high signal-to-noise ratio; can operate empty with power on.
- LOW INSTALLATION COST - only a single conduit between transmitter and signal converter.
- SEALED METER HOUSING - weather resistant-protects coils which are mounted (for easy serviceability) on outside of flow tube. Meets NEMA 4 specifications. Submersible design optional.
- POSITIVE ZERO RETURN - optional zero level locking circuit actuated by remote contact. Holds output signal at zero flow rate value.
- UNAFFECTED BY CHANGES - in conductivity, temperature, pressure, density, and viscosity.
- ADJUSTABLE FLOW RANGES - full scale deflection can be easily set for any flow rate within the limits of the transmitter.
- IMMUNITY TO STRAY VOLTAGES DUE TO UNIQUE ELECTRODE BALANCE SYSTEM - eliminates the need for adjustments.
- LONG CABLE LENGTH - distance between transmitter and signal converter is not limited by the conductivity of the liquid.
- ELECTRODE CLEANERS - optional ultrasonic, or mechanical scraper in only complete line of cleaners available. Cleaners prevent accumulation of matter on transmitter electrodes which could affect metering accuracy.
- PROTECTIVE SHIELD/GROUNDING RING - (optional) prevents damage to meter lining materials when handling abrasive and solids-bearing liquids.

Where it is not desired to time-share one signal converter with several electromagnetic flow transmitters, Models 7700-7800 are available. These models are essentially a Model 7100-7200 flow transmitter with an integrally-mounted signal converter. Figure B depicts typical configurations.

TYPICAL SIGNAL OUTPUTS

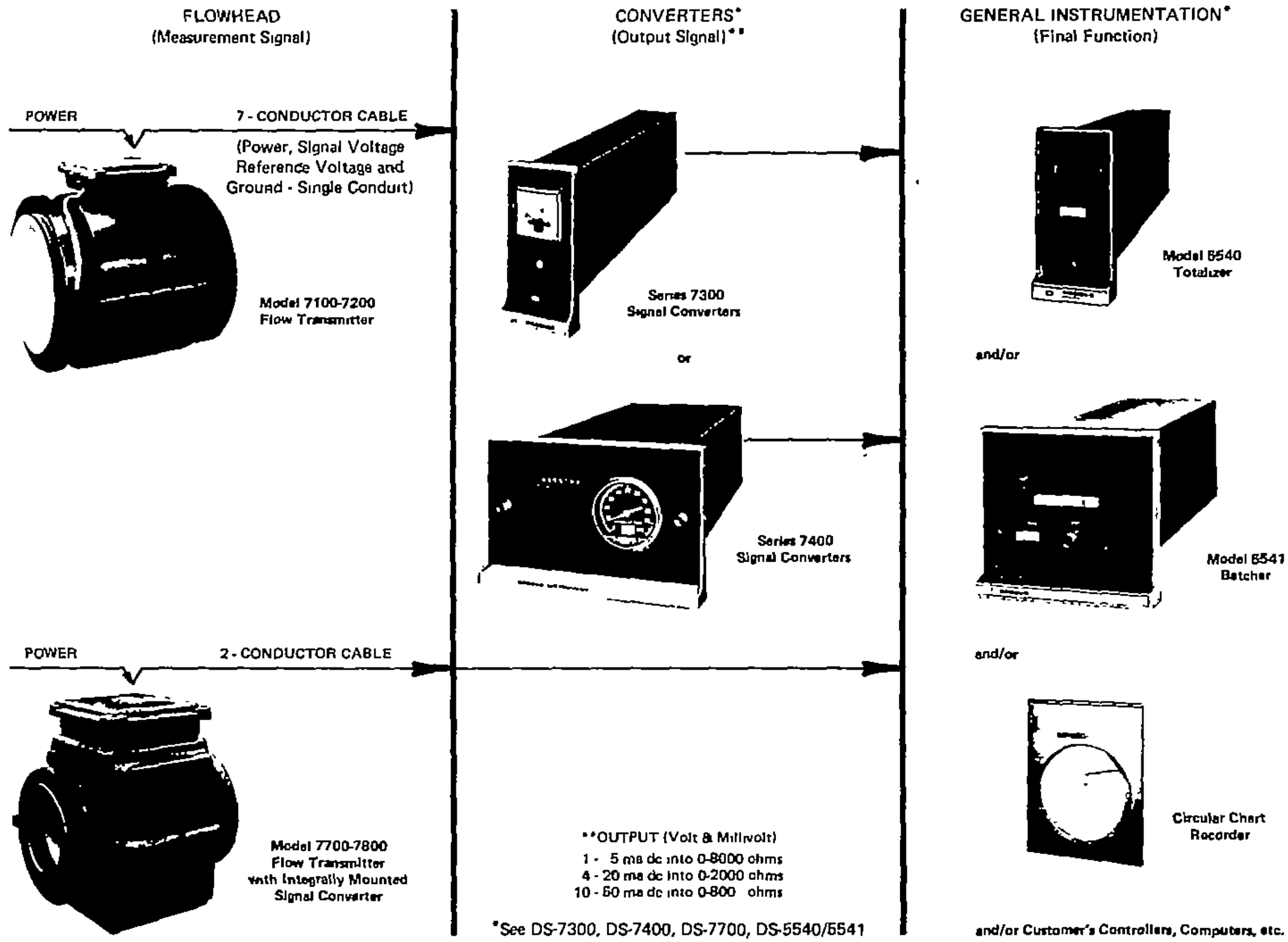


Figure B

Secondary Devices

Signal Converters - Series 7300 Signal Converters are all solid state instruments which receive the electrical output signals that are linear with flow rate. There are no servo motors, balancing slidewire, or other components that can wear out. The Brooks Model 7300 Series Signal Converter amplifies and converts the AC output signal from the flowhead into a DC signal. Since the DC signal is directly proportional to the liquid flow rate, it is used to drive a meter on the signal converter that indicates percent of maximum flow. The DC signal can be adjusted for various operating ranges, and can be used with indicators, controllers, recorders, and systems that require direct current inputs for operation.

The AC flow rate signal from the flowhead is coupled into an impedance converter having an input impedance of approximately 2000 Mohms. The signal is amplified, converted to DC, and coupled to a divider. Similarly, the reference voltage from the flowhead is converted to DC, amplified, and coupled, in the proper sense, to the divider. A constant DC multiplier signal (factory pre-set) is coupled to the divider for scaling purposes. The specific function of the dividing feature is to produce a ratio between the signal and reference voltages for all specified flow rates. Fluctuations of primary power causes proportional fluctuations of both signal and reference voltages. Therefore, by maintaining the ratio constant for a given flow rate, the primary power fluctuations are ignored. The computed output signal is then conditioned as required and transmitted to the users receiving devices.

Series 7400 Signal Converters are all solid state devices which receive the electrical outputs from Brooks electromagnetic flowmeters and convert these outputs to useable electrical output signals that are linear with flow rate. The signal converters are integrated units of modular design capable of high system accuracy with a minimum of components. The Brooks Model 7400 Series Signal Converter amplifies and converts the AC output signal from the flowhead into a DC signal, or a pneumatic signal. Since the signal is directly proportional to the liquid flow rate, the meter on the signal converter directly indicates percent of maximum flow. The output signal can be adjusted for various operating ranges and can be used with indicators, controllers, recorders, and systems that require DC or pneumatic inputs for operation.

The electrical output from the electrodes in the flowmeter is amplified by a high impedance preamplifier. This signal is combined with a reference signal and then fed to a servo-amplifier which, in turn, powers a servo-motor. The servo-motor drives a totally enclosed slidewire to achieve a true null-balance by balancing a reference voltage (fed through the slidewire) against the signal voltage. In addition, the servo-motor operates the pointer which indicates flow rate, and also rotates the cam which actuates the pneumatic transmitter or integrator.

Design features common to both the Series 7300 and 7400 signal converters include:

- HIGH ACCURACY - Standard accuracy is ±0.5% full scale output.
- COMPLETE INTERCHANGEABILITY - All units interchangeable with each other and with other signal converters from Brooks.

SUMMARY OF 7400-SERIES SIGNAL CONVERTERS

Model Number	READOUT					
	Flowrate Indicator Dial	7-Digit Counter	Pneumatic Signal Output	Current Voltage Output	Output Resistance	Telemetry
7410	Yes	-	-	-	-	-
7411*	Yes	-	-	-	-	-
7430	Yes	Yes	-	-	-	-
7431	Yes	-	-	-	-	Yes
7450	Yes	-	Yes	-	-	-
7460	Yes	-	-	Yes	-	-
7470	Yes	Yes	Yes	-	-	-
7475	Yes	Yes	-	Yes	-	-
7490	Yes	-	-	-	Yes	-
7495	Yes	Yes	-	-	Yes	-

* 8-1/2 inch indicator dial

- LINE VOLTAGE COMPENSATION - Inherent compensation for line voltage variations.
- EMPTY PIPE ZERO - Output goes below zero when flowmeter electrodes are not exposed to conductive liquid (standard).

- MULTIPLEXING - One signal converter can be time shared with several flowmeters.

- LEAD LENGTH - Signal is not affected by lead length.

- MINIMUM INSTALLATION COST - Only one conduit is required between flowmeter and signal converter.

- MULTIPLE RANGE - Front-of-panel range selection available, or ten-turn potentiometer mounted on printed circuit board (optional).

- SERVICEABILITY - Chassis may be pulled out for inspection without shutting down flow or interrupting output.

- MOUNTING - Cases available for flush panel, wall or pipe-stand mounting. Cases available in standard, weather-proof, or explosion proof construction.

Continuous Level Measurement and Control Systems - The Brooks "Maglink" liquid level system was specially designed for use in pressurized tanks or in open vessels in chemical service, where severe conditions of corrosion, temperature, and pressure may occur. All parts in contact with the liquid are made from stainless steel, plastic, or special materials, thus enabling the equipment to be used for most applications in the chemical, food, and allied industries such as liquified gases, acids, etc. The "Maglink" magnetic system has a sufficiently strong coupling to withstand even the most severe fluctuations in liquid level within the tank. The unit is schematically illustrated in Figure C.

Any change in liquid level moves the float, which contains an annular magnet. The float traverses a sealed guide tube. The flux linkage between the float magnet and the tape magnet within the tube transmits the movement via the tape, to the indicating mechanism in the head. Backlash in the indicator mechanism is completely eliminated by means of a constant torque spring, which also serves as a take-up device for the tape and compensates for the weight of the magnet. The density of the liquid is accomodated by the range of floats available. Design features of the unit include:

- Sealed system - for pressure or vacuum service
- Materials of construction for corrosive service
- High accuracy
- No calibration required

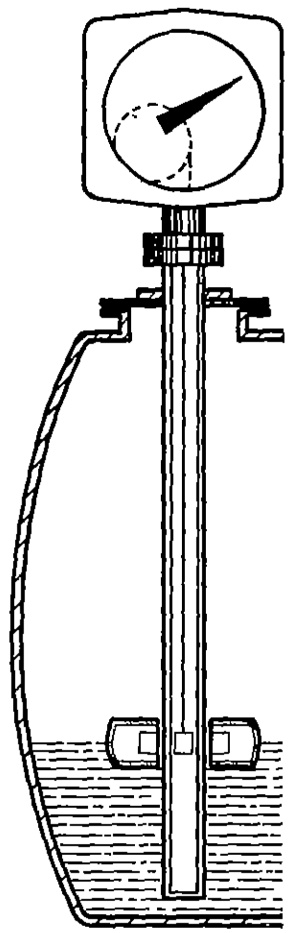


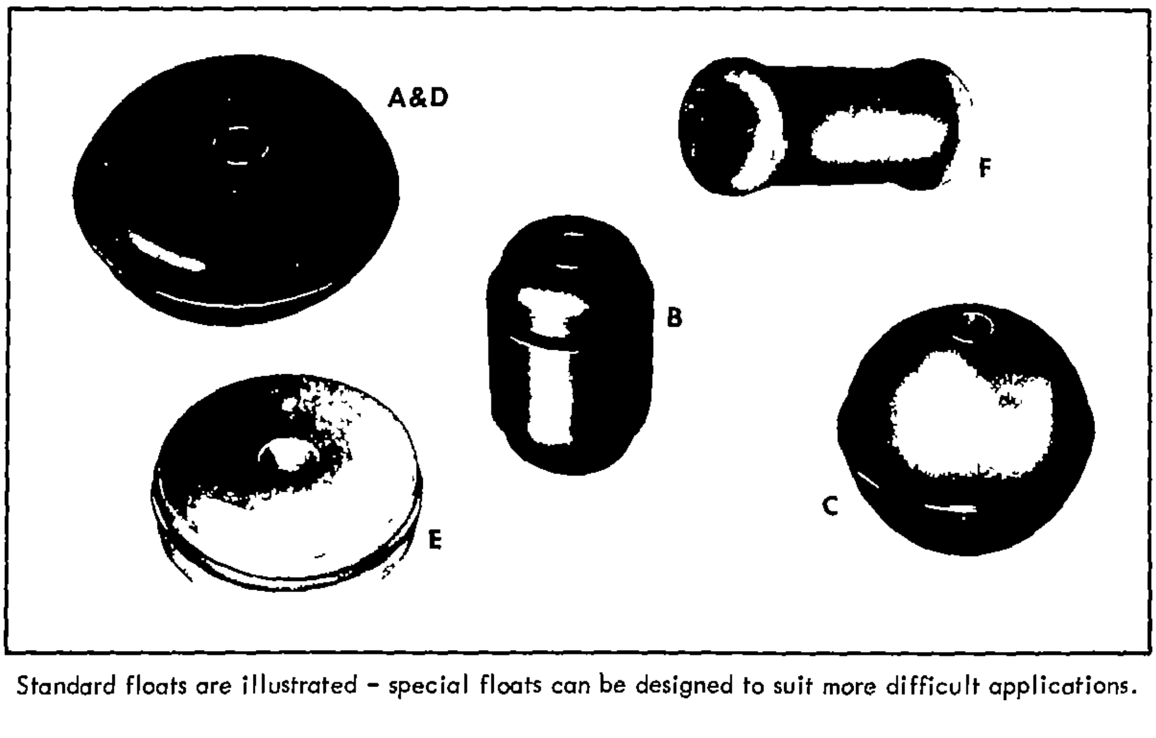
Figure C

- Remote transmission, pneumatic or electric
- Good readability - 25.4 cm (10 in.) direct reading dial
- Mechanical operation, inherently explosion proof
- Unaffected by foam
- Simple to operate and maintain
- Operates on any liquid specific gravity
- Interface measurement
- Weatherproof case (standard for 25.4 cm dial only)

- Typical float designs are as follows:

Diameter Inches	mm	Height Inches	mm	Min. Liquid Density in gm/cm^3	Max. oper. pressure PSIG	kg/cm^2	Max. oper. temperature °C	°F	Float Identification	Float Application
Floats in Stainless Steel										
9-1/2	241	3	76	0.55	50	3.5	250	480	$\boxed{A}$	for standard use
5-1/2	146	5	127	0.85	150	10 5	250	480	B	for small branch entry
7-1/2	190			0.55	350	22.5	250	480	C	for medium pressures
8-1/2	216			0.45	250	17.5	250	480	C	same
10-1/2	266			0.28	120	8.5	250	480	C	same, and for low density liquids
Floats in Polypropylene, Polyethylene, PVC										
9-1/2	241	3	76	0.55	15	1.0	100	220	$\boxed{D}$	for standard us_
7-1/2	190	2-1/2	64	1.1	300	21 0	100	220	E	solid-for high pressure applications
4-3/4	121	5-1/2	140	0.85	100	7	100	220	F	for small branch entry
3-1/2	89	7	178	1 1	100	7	100	220	F	same
Glass Float (Pyrex)										
5-3/4	146	7	178	0.68	45	3.2	250	480	G	For highly corrosive applications
Interface floats										
6	152	2-3/4	70	See	200	14.0	100	220	E*	for interface measurement with
7-1/2	190	2-1/2	64	note	300	21.0	100	220	E**	adjustable weights

Minimum difference in liquid density 0.2 gm/cm^3
* Stainless Steel ** Polypropylene, PVC, Polyethylene ☐ Recommended float design



Standard floats are illustrated - special floats can be designed to suit more difficult applications.

- Materials of Construction include:

  Guide Tubes and
  Mounting Flange - Std.: 316 SS, Polypropylene, PVC
  Optional: Teflon-covered SS

  Floats - Std.: 316 SS, Polypropylene, PVC
  Optional: Glass, Monel

  Cases - Die-cast Alum. (with transmitter or switch)
  Rigid polyurethane cover & fiberglass housing (std.)

- Ranges:

  Dials - Any range from 0 to 2 ft (min.) to 0 to 36 ft (max.)

  Tapehead - Any range from 0 to 2 ft (min.) to 0 to 16 ft (max.)

- Scales:

  Standard — Graduated in ft., in., or mm.

  Special — Graduated in units of weight or volume of material

- Performance:

  Sensitivity -

  All units below 5.5m (18 ft) - float movement ±1.6 mm (1/16 in.)

  All units 5.5 to 10.9m (18 to 36 ft) - float movement ±3.2 mm (1/8 in.)

  Accuracy - ±0.5% of max. indicated depth

PRICES:

"Brooks-Mag" Flowheads	\$800-\$17,000
"Brooks-Mag" Signal Converters	\$600-\$12,000
"Maglink" Liquid Level Systems	\$200-\$1,200

COMMENTS:

Electromagnetic flowmeters were discussed generically in Section VI and no further comment will be made here. The "Maglink" liquid level system could find some application as a secondary device in conjunction with flumes and weirs, especially in difficult sites. All Brooks equipment outputs are computer-compatible either as standard design or available option.

MANUFACTURER: CONTROLOTRON CORPORATION
176 CONTROL AVENUE
FARMINGDALE, L.I., NEW YORK 11735
TELEPHONE (516) 249-4400

PRODUCT LINE: ULTRASONIC FLOWMETERS

DESCRIPTION:

Controlotron Corporation manufactures the Series 240 clamp-on ultrasonic flowmeter consisting of both a primary clamp-on unit and a secondary flow display computer and readout unit for use with pipe sizes from 2.54 to 152.4 cm (1 to 60 in.) in diameter. The acoustic technique employed is independent of liquid temperature, viscosity, turbulence, etc. The simple clamp-on installation requires no calibration or cutting of metal and can be performed by non-technical personnel. The Series 240 transducer consists of a transmitter and receiver unit positioned on opposite sides of the pipe. The transmitter, controlled by the flow display computer, injects an ultrasonic sound beam into the liquid through the pipe wall. The sound beam impinges on the receiver after passing through the liquid and the pipe wall adjacent to the receiver. If the liquid is flowing in the direction of the sound beam, the apparent speed of sound in the liquid is increased (or decreased if flowing opposite to the sound beam).

The pipe construction and the type liquid within determine whether or not the Series 240 ultrasonic flowmeter is suitable for a particular application. Controlotron will test 0.24ℓ (8 oz) samples of the liquid and samples of the pipe at no cost to the user to determine suitability. Applications for which clamp-on models are not recommended by Controlotron include pipes made of cast iron or any other material with an irregular exterior or on pipes with linings that would attenuate the acoustic signal. Insert transducers are used for this type of service. These are similar to the transducers that are used for open stream or channel measurement, and are made to order based upon the application specifications. Controlotron does not recommend use of ultrasonic velocity measurement devices in liquids that are high in undissolved solids or gases, e.g., slurries of sand-like particles, foams, or other aerated liquids, etc. Very rapid (less than 60 seconds) changes in liquid characteristics (that would change its sonic velocity) will result in temporary self-calibration failure and erroneous readings.

SPECIFICATIONS:

Flow Range:	0-9.1 m/s (0-30 fps)
Resolution:	0.0015 m/s (0.005 fps)

Accuracy:	From ±0.25% to ±2%, with ±1% of Full Scale Reading nominal. Larger sizes are more accurate, and Controlotron will quote expected accuracy for a given application.
Repeatibility:	±0.05%
Indication:	Standard 3-1/2 Digits
Outputs:	Digital - BCD
	Optional - Analog 0-10V, 4-20 mADC
	Totalizer - 6 Digits
	Alarm - Settable Hi and Lo Flow Alarms
Power:	115/230 VAC, 50-60 Hz, 75 watts

Dimensions:

Transducer - L = Pipe O.D. + 15.24 cm (6 in.) (Approx)

Flow Display - 25.4x33.0x38.1 cm (10x13x15 in.)

Counter - 20.3x30.4x35.6 cm (8x12x14 in.)

PRICE:	Starts at approximately $2,000 for a 25.4 cm (1 in.) pipe.

COMMENTS:

The equipment is factory calibrated either with water or the intended liquid, as appropriate. This is for fully developed flows with Reynolds numbers exceeding 10,000. It can be calibrated for any flow including laminar, and Controlotron reports that models with settable flow range factors and tracking of flow profile through the laminar flow region will soon be available. A zero offset adjustment may be required upon installation. Experience in metering raw sewage with this equipment is limited at this time and no definite statements about its suitability can be made. The manufacturer is expanding its product line and adding new features that may well increase the likelihood of their successful use as flowmeters for storm and combined sewer discharges (but not in the clamp-on configuration for most installations). An acoustic level gage that could be used with a number of primary devices such as weirs and flumes is also under development.

MANUFACTURER: COX INSTRUMENT
DIVISION OF LYNCH CORPORATION
15300 FULLERTON
DETROIT, MICHIGAN 48227
TELEPHONE (313) 838-5780

PRODUCT LINE: VARIABLE AREA FLOWMETERS; TURBINE FLOWMETERS; FLOW NOZZLES; FLOW INDICATORS

DESCRIPTION:

Primary Devices

Cox Instrument has long been recognized as a manufacturer of precision flow measuring equipment, especially as related to fuel, oil, gas, and industrial process fluid flows. The company proudly claims that "over 95% of the world's commercially-built liquid flowmeter calibrators now in use were designed and fabricated by Cox Instrument." This includes one presently being used by the National Bureau of Standards. Cox has also produced custom designs and systems for special applications.

The company offers a wide line of variable-area flowmeters. Such devices are not considered at all suitable for storm or combined sewer applications and, hence, will not be discussed. Cox also has a very wide line of turbine meters; capacities range from 0.00044 to 1770 ℓ/s (0.000016 to 62 cfs), with accuracies to 0.05% of reading available and response times better than 50 milliseconds. One of these typical turbine meters is shown in Figure A, which also indicates some of the distinguishing features of a Cox turbine. Turbine flowmeters are not considered suitable for most sewer flows and will not be discussed further.

Cox also makes a flowmeter called the VR-30 which, it is claimed, presents a new concept to the field of industrial flow measurement. It uses the principle of variable reluctance: a spring-loaded, force-balance spool is displaced in a magnetic field by the force of fluid flow. This changes the coupling in an external circuit. Because the spool is displaced in a contoured cross-section, the square root is extracted automatically, resulting in a linear output. The advantages to this approach are bi-directional output; unrestricted mounting position; in-line installation; and low maintenance operation. The VR-30 is said to handle corrosive, toxic, contaminated, or volatile fluids or slurries, at pressures to 3,000 psi and temperatures to 121°C (250°F). It is accurate to ±2% of full scale. Prices start at under $300, complete with remote indicator. The VR-30 may also be purchased with a more sophisticated readout device for analog and pulse output, providing for continuous process control or direct computer input.

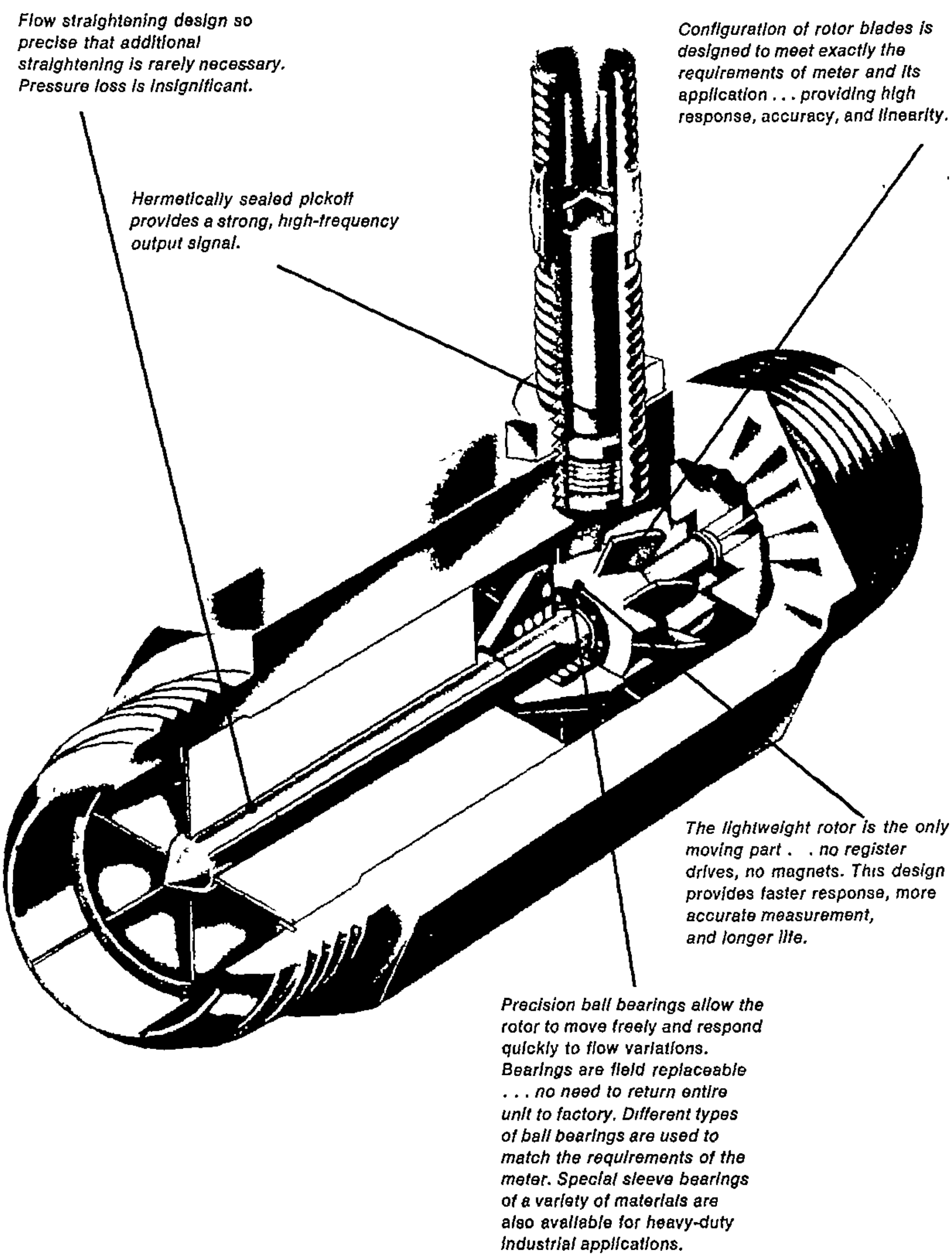

Flow straightening design so precise that additional straightening is rarely necessary. Pressure loss is insignificant.
Configuration of rotor blades is designed to meet exactly the requirements of meter and its application . . . providing high response, accuracy, and linearity.
Hermetically sealed pickoff provides a strong, high-frequency output signal.
The lightweight rotor is the only moving part . . no register drives, no magnets. This design provides faster response, more accurate measurement, and longer life.
Precision ball bearings allow the rotor to move freely and respond quickly to flow variations. Bearings are field replaceable . . . no need to return entire unit to factory. Different types of ball bearings are used to match the requirements of the meter. Special sleeve bearings of a variety of materials are also available for heavy-duty industrial applications.

Figure A

This device may have some wastewater applications, but is not considered well suited for most storm or combined sewer flow measurements. It will not be discussed further.

Cox manufactures twenty standard sizes of flow nozzles (Figure B) in two series with bore diameters ranging from 0.3 to 22.9 cm (0.128 to 9 in.). The standard approach to bore diameter ratio is 3:1, but the

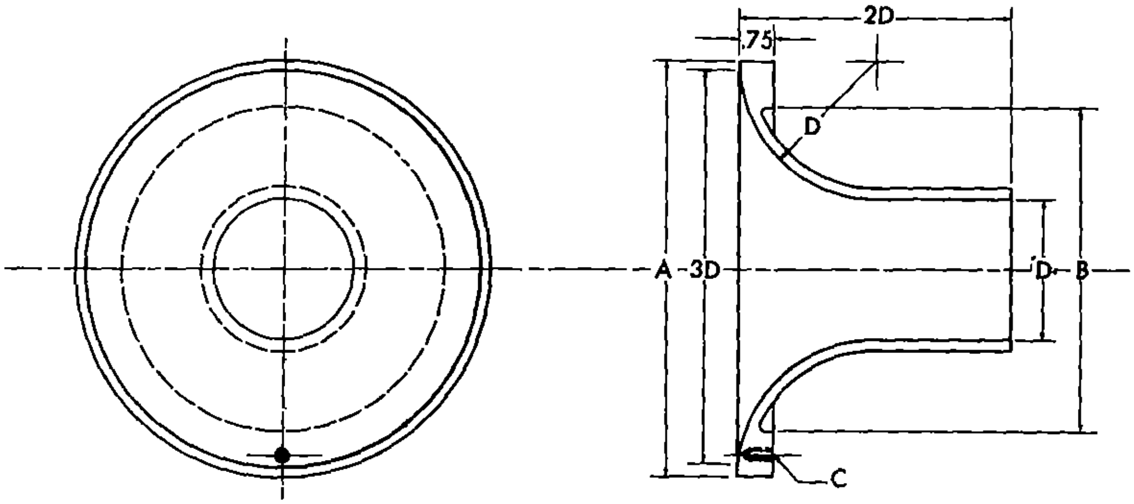


Figure B

larger sizes are available on request in a 2:1 ratio. Cox nozzles are available either calibrated or uncalibrated. Nozzles are calibrated by using a positive displacement prover tank, a standard "Master" orifice, or both. Pressure differential across the nozzle is determined by using a micromanometer accurate to 0.005 cm (0.002 in.) of water. Standard calibration is to within ±1.0%. With calibrated nozzles, a curve of "Differential Pressure versus Flow Rate" (based on 14.7 psia and 70°F) is supplied with a copy of actual calibration data and correction factor determinations. Calibration at other than the standard condition noted can be obtained on special order. Flow nozzles were thoroughly discussed in Section VI and will not be commented on again here.

Secondary Devices

In addition to turbine meter signal conditions and displays, Cox manufactures a number of basic electronic modules for signal conditioning, conversion, display, etc., that could be used as "building blocks" in assembling a custom system. One such unit will be described as an example, but such basic components lie outside the general scope of this writing.

Cox Variable Time Base P1B - Using integrated circuit (IC) techniques, the P1B module provides signal conditioning of low level AC signals for input to counters. The P1B may be used to increase the flexibility of almost any counter currently made. It is not limited to Cox-built equipment, and will interface with most major manufacturers' counters. In addition to signal amplification and conditioning, the P1B module provides gate, reset, and display control of ancillary counters. The variable time base (gate control) is a direct setting digital selector. A four digit time base selector permits selection of 0.000-10.000 seconds gating time in steps of 0.001 seconds. The time base affords an easy means of displaying the frequency output of a transducer in direct reading units (e.g., GPM, RPM). The P1B may be used with Cox P3A coun counter for the direct display of a frequency signal in engineering units. Turbine meters produce a frequency proportional to flow-rate. By preselecting appropriate gate time, the display is in GPM units.

Design features include:

- Advanced IC design employed.
- TTL (transistor-transistor logic) assures superior noise immunity.
- Designed for compatibility with pulse transducers present or future.
- Standard high sensitivity (3 mV) eliminates need for intermediate transducer amplification.
- Short circuit protection against both installation error and ancillary equipment failure.

MANUFACTURER: CUSHING ENGINEERING INC.
3364 COMMERCIAL AVENUE
NORTHBROOK, ILLINOIS 60062
TELEPHONE (312) 564-0500

PRODUCT LINE: ELECTROMAGNETIC WATER CURRENT METER

DESCRIPTION:

The Series 600 VELMETER, an electromagnetic water current device, is designed to measure flow velocity in oceans, streams, rivers, estuaries, aqueducts, sewers, etc. Operational features include no moving parts, zero threshold, fast response times, cosine response, special noise rejection circuitry, linear output, and anti-fouling coating.

The meter consists of a flow sensor connected to a signal converter by means of a cable and is offered in several configurations. These include an explosion-proof housing, NEMA 4 (weatherproof) housing, portable housing, rack-mounted panel, and kit form for the converter unit; 60-Hz or battery power; flange connection (with No-Foul protection) type sensor; or streamlined type sensor (for use when flow direction is known).

The VELMETER sensor produces a flow-generated voltage of approximately 20 MV per 0.3 m/s (1 fps) of flow velocity. The sensor's electromagnet requires a (rms) constant current drive, which is provided by the signal converter. The converter accepts the flow-generated voltage from the sensor, amplifies it, and conditions it to produce a final analog voltage output of ±5 volts for ± full scale flow. The converter also conditions the signal to provide optimal filtering of spurious wideband noise that is picked by the sensor (such as 60-Hz noises generated in waters near urban and industrial areas).

There are several sensors that can be used with this metering device. The Series 501 sensor incorporates one pair of detection electrodes and provides an output voltage proportional to the vector component of flow perpendicular to both the line connecting the two electrodes and to the axis of the sensor. The series 502 incorporates two pairs of detection electrodes and provides two output voltages, measuring two vector components of water flow. The series 81/82 sensors are, respectively, single-component and two-component devices which produce approximately six times the flow signal power of the Series 500 sensor; this sensor is said to perform within specifications for flow velocity up to 15.2 m/s (50 fps).

SPECIFICATIONS:

Range:	Full Scale, adjustable to 0.09, 0.30, 0.9, 3.0, or 9.14 m/s (0.3, 1, 3, 10, or 30 fps)
Output Time Constant:	Adjustable to 0.1, 0.3, 1, 3, or 10 seconds

Maximum Error Band:

	CONVERTER MODEL NO. 611/612	CONVERTER MODEL NO. 631/632	UNITS
Span or linearity	±1	±2	Percent of Full Scale
Zero Offset	±0.01	±0.05	Feet per second
Random Noise, rms*			
Series 500 sensor	$0.006/\sqrt{T}$	$0.030/\sqrt{T}$	Feet per second where T is the output time constant in seconds
Series 80 sensor	$0.002/\sqrt{T}$	$0.010/\sqrt{T}$	
Series 80 sensor with Magpower option	$0.001/\sqrt{T}$	$0.005/\sqrt{T}$	

* Apparent peak-to-peak noise on a recorder depends largely on chart speed; but approximately, apparent peak-to-peak noise is 6 times rms. value.

PRICE: $2,000 - $3,000 depending upon configuration.

COMMENTS:

This device should find some use as an attended survey unit in its portable configuration. Because of the obstruction to the flow offered by the standard probe configuration, some ingenuity would have to be exercised in mounting if damage from debris in the flow is to be avoided.

MANUFACTURER: DANIEL INDUSTRIES, INC.
P.O. BOX 19097
HOUSTON, TEXAS 77024
TELEPHONE (713) 467-6000

PRODUCT LINE:

PRIMARY DEVICES - ORIFICE PLATES AND METERS, TURBINE METERS, FLOW NOZZLES

SECONDARY DEVICES - DIFFERENTIAL PRESSURE TRANSDUCERS, TRANSMITTERS, AND CONVERTERS, INDICATORS, AND TOTALIZERS (CALLED FLOW COMPUTERS)

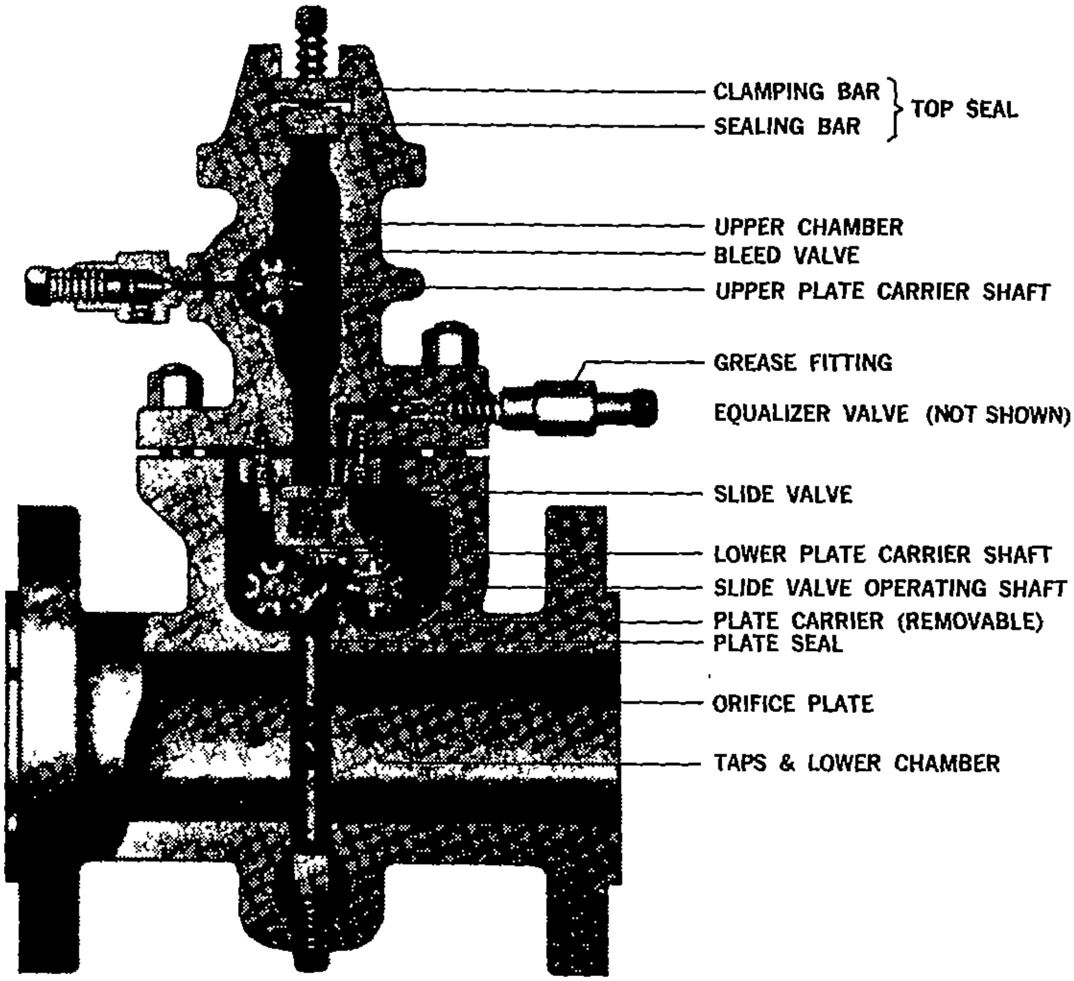
DESCRIPTION:

Primary Devices

Daniel Industries, Inc. manufactures a full line of orifice plates and flanges, orifice metering tubes, bored orifice flow sections, and orifice fittings for line sizes varying from 0.6 cm (1/4 in.) to 1.5m (4 ft) in diameter. Their "Senior" orifice fittings have a dual chamber design (Figure A) that permits the orifice plate to be removed from pressure lines safely and quickly; this facilitates regular inspection and maintenance. "Junior" orifice fittings and "Simplex" orifice plate holders are made for application where line by-pass or pressure shut-down is permitted. A large range of orifice flanges for use where it is not necessary to make regular plate inspections is also offered, as are orifice meter tubes and bored orifice flow sections for use where greater accuracy is required.

Daniel manufactures a "PT" line of liquid turbine meters (Figure B) in sizes from 1.3 cm (1/2 in.) to 61 cm (24 in.). These meters are intended for use where highly accurate measurement of large liquid volumes is required, e.g., custody transfer. Each meter can be fitted for bi-directional flow. Normal (linear) flow ranges are around 10:1 and extended flow ranges are from around 15:1 to 40:1, depending upon size.

Daniel also manufactures a full line of precision flow nozzles (ASME long radius and ASME throat top) including flanged, weld-in, and holding ring types in a wide variety of materials (Figure C). For highest metering accuracy, a fully assembled flow nozzle and meter tube is offered. Large volume custom meter stations and proving systems are supplied in virtually any size and capacity.



SIDE SECTIONAL VIEW

Figure A

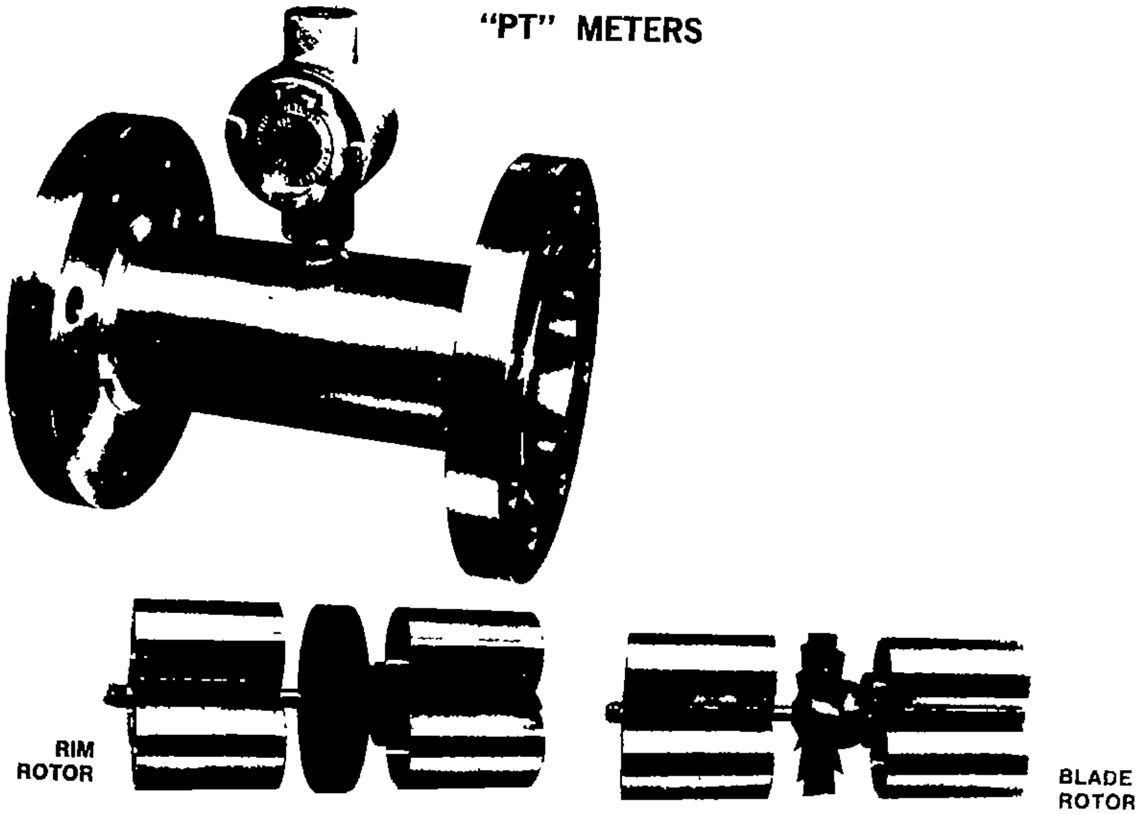
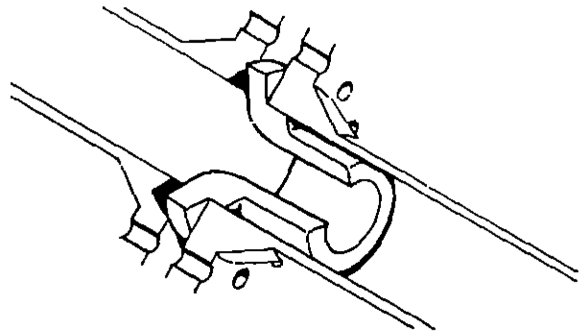
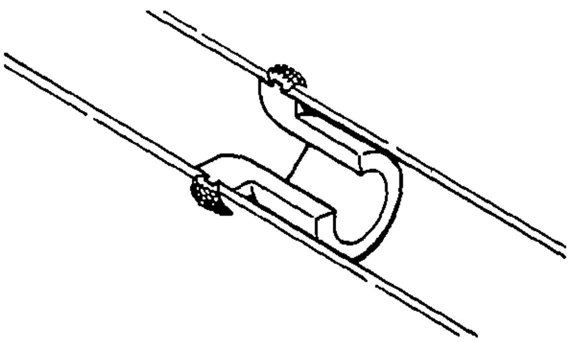


Figure B

FLANGED
FLOW NOZZLE

This type of nozzle has a flange on its upstream end which is installed between pipe flanges to hold the nozzle concentric with the inside of the pipe The nozzle flange can be furnished in any series of facing (raised, ring-joint, etc) specified





WELD-IN
FLOW NOZZLE

This nozzle has a machined tongue around its greatest diameter which fits between beveled ends of both an inlet and outlet pipe section The sections, with the nozzle in place, are firmly clamped and/or tack-welded together in perfect alignment before the finish weld is applied.

HOLDING RING
FLOW NOZZLE

This nozzle is another welding type for installation in pipe without flanges The nozzle is installed in a section of carefully selected and internally bored pipe with the curved nozzle inlet facing upstream

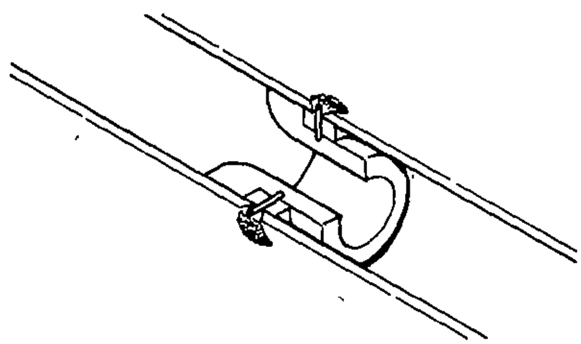


Figure C

Secondary Devices

Daniel supplies a wide range of differential pressure transducers, transmitters, counters, and indicators and totalizers (called flow computers) for use with all of its primary elements. A typical differential pressure flow computer might take a 4-20 mADC signal that is proportional to pressure difference and convert this into: a visual indication of flow rate on a front panel meter; a 4-20 mADC electrical output that is proportional to flow rate; a visual, six-digit indication of totalized flow; and an electrical dry contact closure per each totalizer advance. Flow rate recordings are not normally supplied, but could be on special order. Similar outputs are available from secondary elements for use with turbine meters.

COMMENTS:

Much of the Daniel product line was developed for the oil and gas industry and is more typically suited for this application than for measuring storm and combined sewer flows. There might be some uses for their flow nozzles and orifice meters in measuring sewage flow, but the turbine meter is not at all suitable. For this reason no detailed specifications or prices will be given.

MANUFACTURER: DREXELBROOK ENGINEERING COMPANY
205 KEITH VALLEY ROAD
HORSHAM, PENNSYLVANIA 19044
TELEPHONE (215) 674-1234

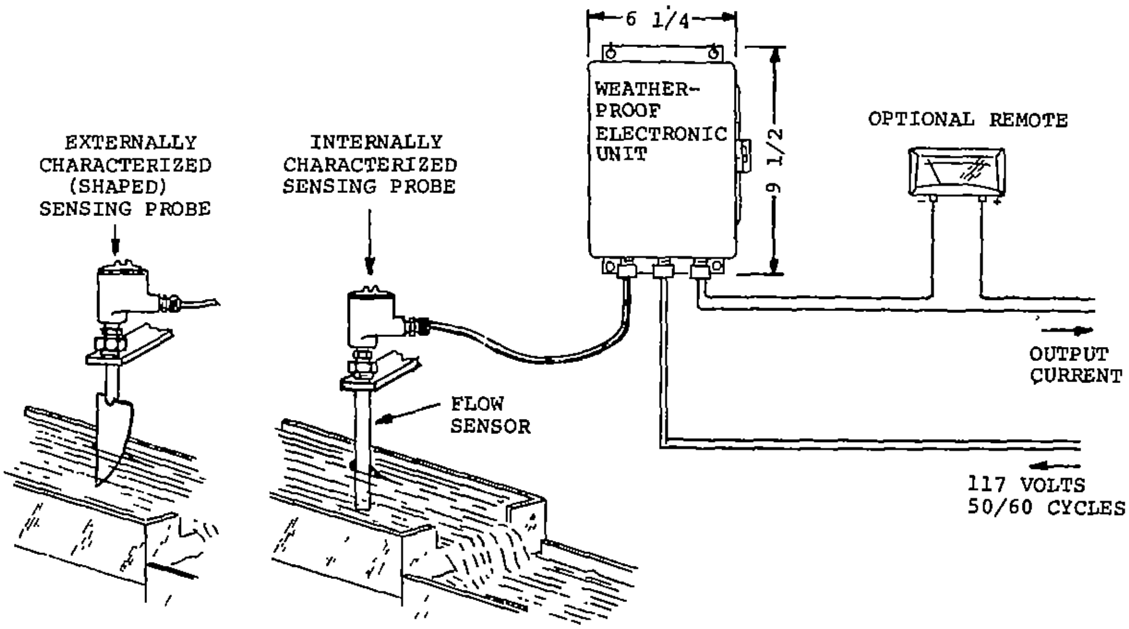
PRODUCT LINE: LEVEL GAGES

DESCRIPTION:

Drexelbrook manufactures a wide line of secondary flow measuring and indicating systems in their Series 508 (see Figure A). The Drexelbrook "Cote Shield" flowmeters provide reliable and accurate measurement of the flow of clean or dirty liquids through virtually any head-area primary device such as flumes, weirs, etc. The flowmeters contain no moving parts, floats, or air purge tubes; they cannot plug, and are unaffected by coating of solids such as slush, mud, algae or slime, build-up, paper, sludge, etc. The sensing element is static and can be installed either directly in the moving stream or in a stilling well.

The sensing element is basically a precision admittance-to-current transducer. It will provide an output current directly proportional to the input admittance presented by the sensing element. Each measured flow rate corresponds to a specific level in the weir or other primary device. This variation in level will cause minute amounts of current to flow from the sensing probe to the grounded stream. A compensated bridge circuit is used to accurately measure the change in current. The output of the bridge circuit is a DC voltage which is a measure of the true flow rate. The output voltage is amplified in a feedback amplifier to provide an output current directly proportional to flow and unaffected by the output resistance. The output current can be used to operate a variety of accessories such as remote meters, recorders, alarm circuits, and electro-pneumatic transducers.

Drexelbrook has a number of the Series 508 models available both with and without "cote-shield" action for clean or dirty liquids that vary in calibrated immersion depth of the sensor probe from 30.5 to 91.5 cm (12 to 36 in.). Standard systems are available for use with any 3/2- or 5/2-power low head-area device (most commonly used with weirs and flumes). Linear systems (e.g., for use with a sutro weir or Kennison nozzle) are routinely made to order, and virtually any depth-discharge characterization can be provided on special request. Both internally and externally (shaped) characterized probes are available. For direct, in-stream applications where damage due to large debris (floating logs, rocks, etc.) is a possibility, Drexelbrook offers an optional tilt-away mounting in which the probe is held in the flow by an adjustable counterweight but is free to pivot up out of the way when struck by an object in the flow. This mounting is also recommended when extreme build-up



SERIES 508 FLOWMETER

Figure A

of fibrous materials such as rags and paper are expected. As large build-ups occur, the increased drag on the probe will cause it to tilt up and allow the fibrous materials to wash away.

Optional integrators (totalizers), batch counters, remote readouts, etc., are available as are such extras as lighted meter case, explosion - proof housings, special mountings including extra-long probes, etc.

SPECIFICATIONS;

Accuracy:	Direct function of primary device. Flowmeter output is linear within ±0.5%.
Standard Output Current Ranges:	4-20 mA thru 0 to 1500 ohms 1-5 mA thru 0 to 6000 ohms 10-50 mA thru 0 to 600 ohms
Load Resistance Effect:	0.1% from 0 to maximum resistance
Power:	95 to 145V, 50/60 Hz with a ±0.5% effect on accuracy for input voltage changes ranging from 95 to 135 VAC. DC operation optional.

PRICES:

Basic Series 508 Systems range from $553.00 to $1,371.00

COMMENTS:

These devices appear very well suited for use with various primary devices to measure storm and combined sewer flows at many sites. They are essentially factory calibrated, and only a few field adjustments are necessary. It should be noted that the entire calibrated length of the sensor is not available for accurate measurement of flow. For example, for 3/2 power law probes, the liquid level should always lie between 1/3 and 3/3 of the calibrated length. Thus, a 51-cm (20-in.) maximum calibrated length sensor should not be used for heads greater than 51 cm (20 in.) nor less than 15 cm (6 in.). An additional interesting feature is that, based upon an application description, Drexelbrook will quote on a guaranteed performance basis. If the equipment does not perform within the quoted specifications, it may be returned for free repair, replacement, or credit.

MANUFACTURER: EASTECH INCORPORATED
2381 SOUTH CLINTON AVE.
SOUTH PLAINFIELD, NEW JERSEY 07080
TELEPHONE: (201) 561-1000

PRODUCT LINE: EDDY-SHEDDING PRIMARY DEVICES; TRANSMITTERS, FLOW CONVERTERS, INDICATORS, TOTALIZERS

DESCRIPTION:

Eastech Incorporated makes the VS-21 series vortex shedding element for the measurement of flows of gases, liquids, and slurries. Also offered is a selection of secondary instrumentation including transmitters for various applications, several flow converters, a digital rate indicator, and a totalizer.

Flowmeters

The VS-21 digital flowmeter (patented under the trade name of VS-21 Flow Transmitter) is the primary flow measuring device, and forms an integral part of various flow transmitters in the manufacturer's product line - both "full pipe flow" type and insertion flow variety. In conjunction with the transmitter and sensor elements, this device utilizes the principle (or effect) of vortex eddy-shedding to measure the flow velocity. The VS-21 generates pulse signals over very wide flow ranges (up to 200:1) at a frequency proportional to the flow rate. It currently utilizes any one of four sensing techniques to measure flow. Three of these techniques employ thermistors; the other makes use of a "shuttle-ball" concept, in which a "captive" hollow nickel ball is driven by the effect of vortex shedding.

In the thermistor techniques, an electrical current is passed through the thermistor, heating it and making it responsive to the cooling effects of flcw. The changes in flow velocity across the thermistor due to vortex shedding result in changes in its temperature, thus resulting in corresponding changes in its resistence. In the front face thermistor technique (Figure A), two coated thermistors are bonded into the front face of the flow element and operated differentially.

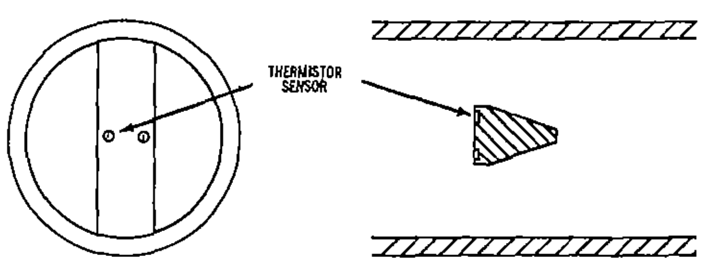


Figure A

The vortex shedding behind the flow element affects the direction of flow impinging on the front face, causing out-of-phase velocity variations at the two thermistors. This is the approach used by Eastech for wastewater and slurry flow measurement applications.

The "central" thermistor technique (Figure B) utilizes a passage drilled through the flow element. The generation of the vortices alternately on either side of the passage causes flow to move back and forth in the passage and across a single, removable thermistor sensor assembly which is mounted through one end of the flow element.

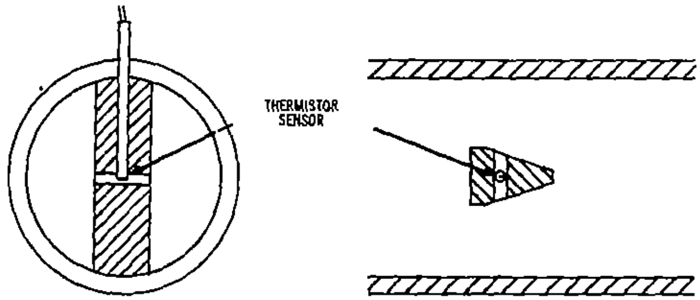


Figure B

The external thermistor technique is similar to that of the central sensor except that it is located in a passage external to the meter. Figure C shows this arrangement.

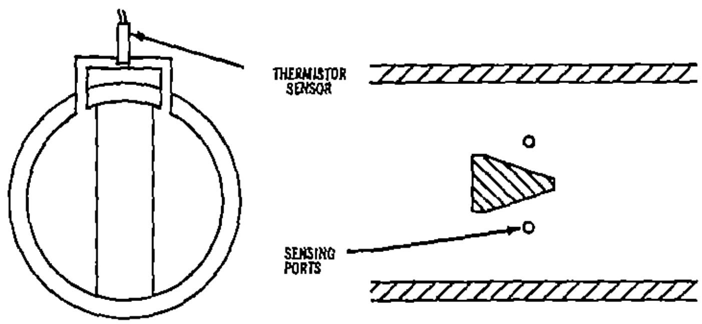


Figure C

The shuttle-ball method (Figure D) employs vortex shedding to drive a hollow nickel ball back and forth along the axis of the flow element. The motion of the ball is detected by a magnetic pickup. The calibration factor of the meter depends only on the dimensions of the flow element and the pipeline.

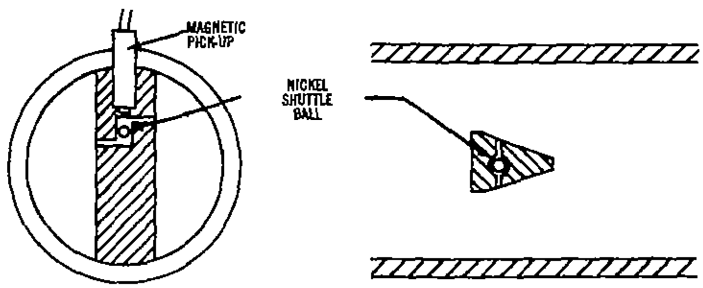


Figure D

Flow Transmitters

As indicated by Eastech, the transmitter models discussed below are the ones recommended for wastewater and slurry applications.

The Model 2210 and 2220 flow transmitters have flanged, spool style bodies and removable VS-21 flow elements. These devices feature two front face thermistor sensors and an explosion-proof, close-coupled solid-state amplifier. This amplifier (also incorporated in the Model 2500/2600 series) is provided to increase signal amplitude prior to its transmission to a flow converter which may be remotely located up to 762m (2500 ft) away. As noted previously, the VS-21 generates output pulse signals at frequencies linear with volumetric flow rate over ranges up to 100:1 (200:1 optional). Basic line sizes are from 3.8 to 15.2 cm (1.5 to 6 in.). Other sizes are optional.

The Model 2510 flow transmitter also employs the front face thermistor technique (Figure A) and has two wet-tap thermistors that can be removed for inspection without interfering with the flow through the device. The thermistors are mounted on removable shafts flush with the face of the flow element. The transmitter may be connected with flow converter instrumentation at distances up to 762m (2500 ft). This model, especially recommended for use on slurries and liquids containing significant amounts of clogging solids, is offered in line sizes ranging from 20.3 to 91.4 cm (8 to 36 in.).

Models 2610, 2620, and 2630 are called "insertion flow" transmitters but are actually velocity probes. These devices have a shrouded flow element with front face thermistor sensors (see Figure A) mounted on the end of a shaft passing through a sealed mounting flange. The fixed model 2610* (Figure E) is used where the line pressure can be relieved

* Also offered is the adjustable model 2640. It is similar to the 2610 except insertion depth can be adjusted with the flow transmitter installed.

for installing or removing the flow transmitter from the line. As stated by the manufacturer, the insertion depth cannot be altered without removing the device from the pipeline, making it in a sense "tamper-proof". The adjustable, hot tap model 2620 (Figure E) can be removed or installed (manually against pressures up to 60 psig) through a block valve without interference with process flow. The model 2630 has a threaded shaft enabling it to be inserted into a high-pressure liquid stream without "blowing down" the pipeline or interrupting flow. Both models 2620 and 2630 are recommended for situations where costs may prevent the use of full pipeline meters, or where it is necessary to remove the metering device for inspection or pipeline "pigging". These transmitters may also be used to traverse across a pipeline to determine velocity profile and are suitable for use in effluent monitoring systems. As with the full pipe flow transmitters, these models can be used with flow converters located up to 762m (2500 ft) away from the site. These transmitters are usable in pipelines ranging from 20.3 to 274 cm (8 to 108 in.).

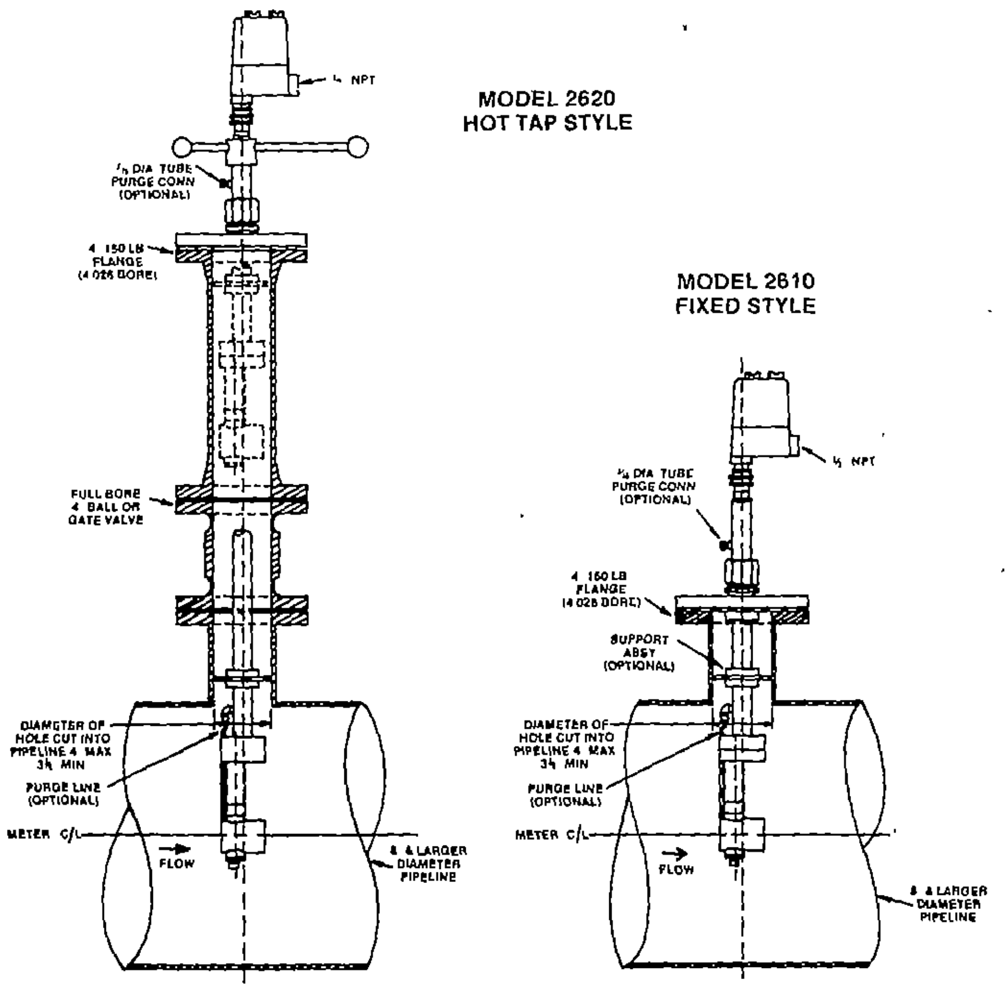


Figure E

Flow Converters/Indicators

Eastech offers several flow converters for use with the VS-21 flowmeter. These include Models 4100 and 4200 and the Model 44 digital flow rate indicator. The 4100 is designed for stationary or over-the-road applications, accepts signals from a VS-21 flow transmitter, and provides a conditioned pulse output. Optional features include scaling to engineering units, totalizers, and analog rate indicators.

Model 4200 is similar to the 4100 except that it provides field adjustable scaling to engineering units and can be panel mounted.

The Model 4400 displays flow rate in digital form. It has a small plug-in module which permits direct reading in any desired engineering units.

SPECIFICATIONS:

Model 2210 and 2510 Transmitters

Repeatability:	±0.1% of reading, or better
Linearity:	±0.5% of reading (at pipe Reynolds numbers of 10,000 and above)
Calibration Accuracy:	±0.25%
Pressure Loss:	0.4 atm at m/s (20 fps)
Response Time:	1 msec @ 500-Hz signal frequency
Minimum Measurable Flow:	Corresponding to pipe Reynolds number of 5,000
Flow Capacity:	2.54 cm (1 in.)* - 302.8 ℓ/s (80 gpm) 91.44 cm (36 in.)* - 340,650 ℓ/s (90,000 gpm)
Turn-Down Ratio:	10:1 & 100:1 (standard); up to 200:1 (optional)

Model 2600 Series Transmitters

Repeatability	±0.1% of reading or better
Linearity:	±2% of reading (at Reynolds numbers 10,000 and above based on flow element dimension of 5.1 or 10.2 cm (2 or 4 in.)

* Meter Size

Calibration Accuracy:	±1%
Pressure Loss:	Negligible
Response Time:	Same as Models 2200/2500 series
Minimum Measurable Flow:	Same as Models 2200/2500 series
Turn-Down Ratio:	Same as Models 2200/2500 series
Element Size	5.1 and 10.2 cm (2 and - 4 in.) diameter

PRICES:

Standard prices not available at the time of this writing.

COMMENTS:

There is necessarily an obstruction to the flow with all of these devices, so their use does not seem appropriate where large trash and debris are present in the flow. A well-conditioned flow is necessary for accurate readings, and a minimum of 20 to 40 pipe diameters in length of straight pipe (15 to 20 diameters if straightening vanes are used) is required upstream of the meter and at least two pipe diameters of straight pipe downstream. Gaskets upstream and near the meter must not protrude into the flow.

MANUFACTURER: EDO CORPORATION
13-10 111TH STREET
COLLEGE POINT, NEW YORK 11356
TELEPHONE: (212) 445-6000

PRODUCT LINE: ACOUSTIC-DOPPLER FLOWMETERS; PROBES, RECORDERS

DESCRIPTION:

The EDO sonic flowmeter operates on the doppler shift principle and is a further development of EDO's line of doppler current meters. The basic parts of the flowmeter (acoustic probe and receiver indicator) are depicted in Figure A.

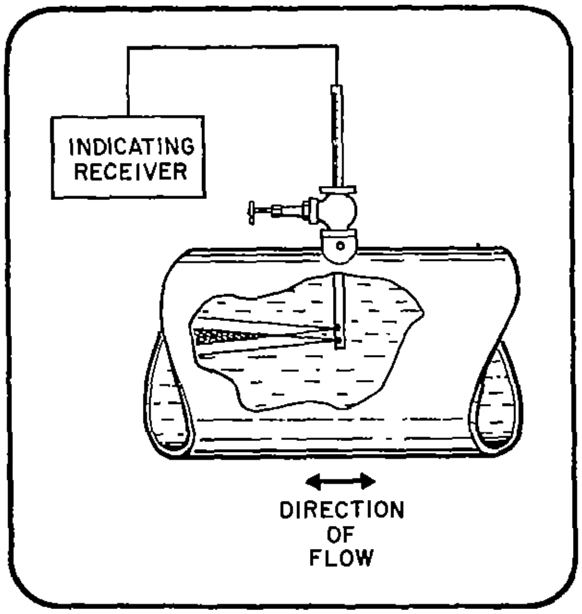


Figure A

An acoustic probe, containing two transducers, is positioned in the flow. It is normally oriented to point upstream, although the probe is actually bi-directional. One transducer projects an acoustic signal, which is reflected by waterborne particles and disturbances. The reflected signal, frequency shifted proportionally to the velocity of the fluid, is received by the other transducer. An electrical signal proportional to fluid velocity is converted to flow rate by means of processing circuits contained in the indicating receiver. The actual point of intersection of the two beams is one foot upstream from the probe, so that measurements are made in an undisturbed region of the flow field. Because the processing circuits are not sensitive to amplitude variations, the flowmeter is immune to changes in impurity concentration and peripheral noise.

Significant claims have been made for this device with respect to its use in wastewater applications. These are:

- The probe does not clog due to sediment or silt as, for example, the pressure ports of various flowtubes;

- The probe does not accumulate undue grease on the sensors, since they are located in a high-velocity region of the flow;

- The probe can be easily wiped free of grease, rags, and other materials because of its cylindrical shape.

In addition to its applications to flow measurements in pipes, the EDO flowmeter can be used for open-channel velocity measurements. The flowmeter has been used in fresh water, salt water, raw sewage and sludge.

EDO provides flowmeters and accessory equipment for both portable use and fixed installation. The model 763F is designed for fixed applications and model 763P is offered for portable uses.

<u>Model 763F</u> - The fixed flowmeter, with its automatic cleaning assembly, is installed at a specific point in the flow system. The cost of an EDO fixed flowmeter installation is essentially constant, regardless of the pipe-diameter, whereas the cost of magmeters, venturis, and similar in-line meters tends to increase dramatically with pipe diameter. Due to its ease of installation, the meter is particularly suited to retrofit applications. If user requirements dictate, it can be used in the interim period while an in-line meter is being repaired. Fixed flowmeter configurations can be altered to meet specific plant requirements. For example, receivers for two or more probes can be packaged in a single receiver unit, and local indicators or totalizers may be installed on the receiver panel.

An automatic wiping mechanism cleans the probe periodically by withdrawing and reinserting it through wiping glands. The period between cleaning cycles is controllable and is set according to existing conditions. The cleaning can be remotely actuated from a control panel, if chart-recorded flow readings indicate the necessity.

The mechanism provides unattended operation and requires only routine preventive maintenance every 6 months. No purging is required.

Model 763P - The portable flowmeter is general plant instrumentation, inserted and removed as required, for plant flow surveys, trouble-shooting, evaluation of equipment, etc. Installation and insertion can be made without interruption of flow. Except for physical dimensions and weight, differences in the respective receiver/indicator configurations, and the fact that it is not equipped with automatic wiping mechanism, the portable flowmeter operates essentially the same as the fixed unit.

SPECIFICATIONS:

Instrumentation	
Flow Range	0.03 - 4.57 m/s (0.1-15 fps)
Pipe Size	15.24 - 243.84m (6-96 in.) dia
Accuracy	±1.5%
Acoustic Probe	
Frequency	3.0 MHz ± .005%
Power Output	1.3 watts
Transducer Spacing	1.9 cm (0.75 in.)
Transducer Angle	20°
Length of Cable Probe	up to 152m (500 ft)
Size of Probes	
Small	1.9x91.4 cm (3/4x36 in.)
Large	5.1x182.8 cm (2x72 in.)
	3.048m (120 in.) (with probe extended)

PRICE:

Model 763F (Probe, Wiper Assembly, Receiver, Chart Recorder, Totalizer)

With Small Probe ---------------------------------- $ 9,345

With Large Probe----------------------------------- $10,300

Model 763P (Indicating Receiver, one Large or Small Probe, Cables)-- $ 2,930

COMMENTS:

These devices are essentially velocity probes and, hence, knowledge of flow velocity profiles is necessary in order to obtain flow discharge. They would appear suitable for open channel as well as full pipe flow given certain constraints. The sensing probe necessarily presents an obstacle to the flow and, in flows containing large trash or debris, it might be physically damaged. Hence, its use would seem inappropriate in this case. Otherwise, the self-cleaning feature would appear to be attractive and could allow its use in troublesome flows. These units are fairly new on the market, and wastewater application data are scant.

MANUFACTURER: ENVIRONMENTAL MEASUREMENT SYSTEMS
A DIVISION OF WESMAR
905 DEXTER AVENUE NORTH
SEATTLE, WASHINGTON 98109
TELEPHONE (206) 285-1621

PRODUCT LINE: ULTRASONIC FLOW MONITOR

DESCRIPTION:

Environmental Measurement Systems, a division of WESMAR (Western Marine Electronics, Inc.), is now in production with their Ultrasonic Flow Monitor, UFM-200, a completely packaged secondary device that "ultrasonically" measures and records continuous liquid flow. The UFM-200 (Figure A) is calibrated, prior to shipment, to the customer's

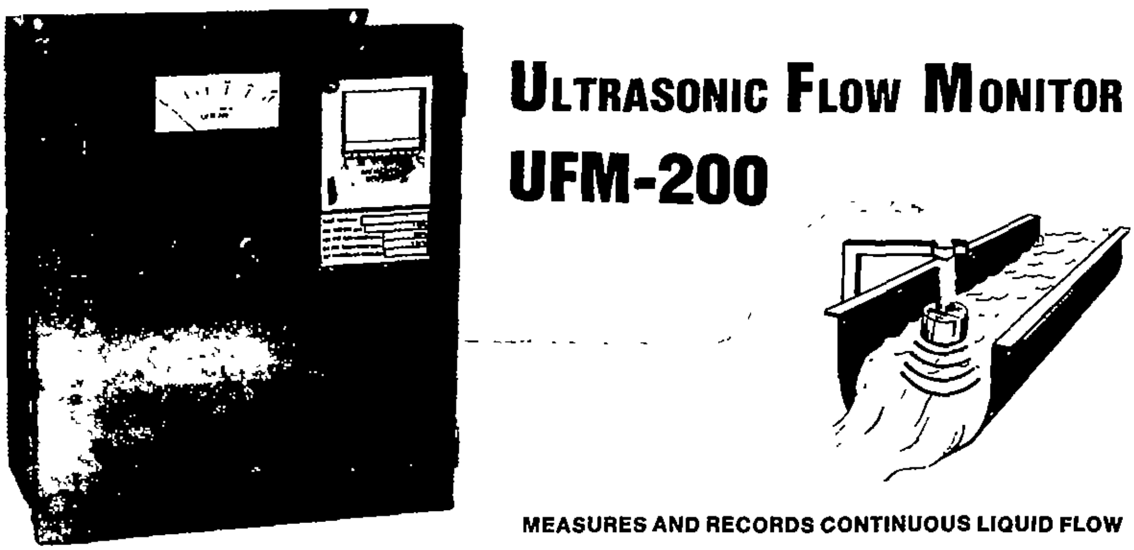


Figure A

flume or weir. There is no contact with material being measured (i.e., transducer is mounted over the weir or flume), since the system operates on the "sonar-in-air" (echo-sounding) principle. The sonar beam gives a constant transmission of the distance from the top level of the flow. This interval is converted to a voltage which is converted to flow rate and recorded, totalized, and displayed. The UFM-200 is a complete system with electronics, total flow counter, water sample rate counter (adjustable), recorder (strip chart), timer (duty cycle), and visual linear readout meter.

The system has built-in circuitry that allows remote or portable installation through battery-powered operation. The total flow counter continuously displays the total amount of flow, in six digits, up to 1 billion gallons (3,785 billion liters); the permanent recorder records the converted and calibrated flow output in gallons per minute on a 6.35-cm (2.5-in.) inkless strip chart at a speed of 2.5 cm (1 in.) per hour.

SPECIFICATIONS:

Range:	3m (10 ft) (maximum) 41 cm (16 in.) (minimum)
Resolution:	within 1%
Repeatability:	within 1%
Linearity:	within 1%
Output Signals:	0 to 5 VDC (proportional to head) 0 to 5 VDC or 0 - 1 MADC (proportional to flow)
Pulse Proportional to Flow:	1 pulse every 1,000 gallons
Sensor Beam Pattern:	7° conical included angle
Remote Operation (Electronics to Sensor Separation):	Up to 91.4m (300 ft)
Input Power:	110/220 VAC, 50 to 60 Hz, 10 watts (or ±12 VDC)
Dimensions	
Enclosure: (JIC)	36x31x15 cm (14x12x6 in.)
Weight:	
Electronics:	15 kg (3 lb)
Sensor:	1 Kg (2 lb)

PRICE:

Not available at time of writing.

COMMENTS:

Some users have encountered difficulty due to echos (false signal returns) when using these devices in manholes. Putting a plastic shield around the transducer seems to solve the problem.

MANUFACTURER: EPIC INC.
150 NASSAU STREET
SUITE 1430
NEW YORK, NEW YORK 10038
TELEPHONE: (212) 349-2470

PRODUCT LINE: CURRENT METERS, COUNTERS/INDICATORS, STAGE MEASUREMENT DEVICES

DESCRIPTION:

Epic Inc. is the U.S.-based outlet for precision instruments and machinery manufactured by the West German firm of A. Ott Kempten. Epic and Ott offer a line of current (velocity) meters and a varied selection of secondary flow measurement devices, including counters, recorders, and indicators and several stage measurement devices (e.g., water level recorders, point gage, and a "flowmeter"). Most of these devices are designed primarily for measurement of water flows, but several have found application in the wastewater field.

Current (Velocity) Meters - Typical current meters in the Epic/Ott line include the Universal types 10.002 (C31), 10.200, and 10.300. Types 10.002 and 10.200 are similar in that they both produce signals generated by an impulse device actuated by a permanent magnet so that the rotation of the propeller is not slowed down by a contact system; the signals are totalized by an electromagnetic counter connected by cable to a magnetic switch, mounted in the meter body. It has been reported that the Type 10.002 (C31), shown in Figure A, has been used successfully (in conjunction with a specially-designed flow tube) by at least one large municipal government in the measurement of effluent flows. Types 10.002 (C31) and 10.200 are portable, battery-powered devices.

Type 10.300 is a permanent hydrometric flow measurement device. Unlike the 10.002 and 10.200, this instrument permits a direct determination of flow velocity and can be permanently installed. As do the other two current meters, the 10.300 produces a signal voltage that is proportional to water speed; this voltage can be read from an indicator in m/s. Telemetry of the measurements is possible.

The type propeller used, and its diameter and pitch, is determined by maximum flow velocity of the fluid into which it is placed. As shown in the following table, there is a variety of propellers for several applications -- including oblique flows as well as straight flows.

A variety of methods for indicating and recording flow velocities is available: direct indication via a servo system (for precision remote indication); four-digit digital readouts by a converter and readout

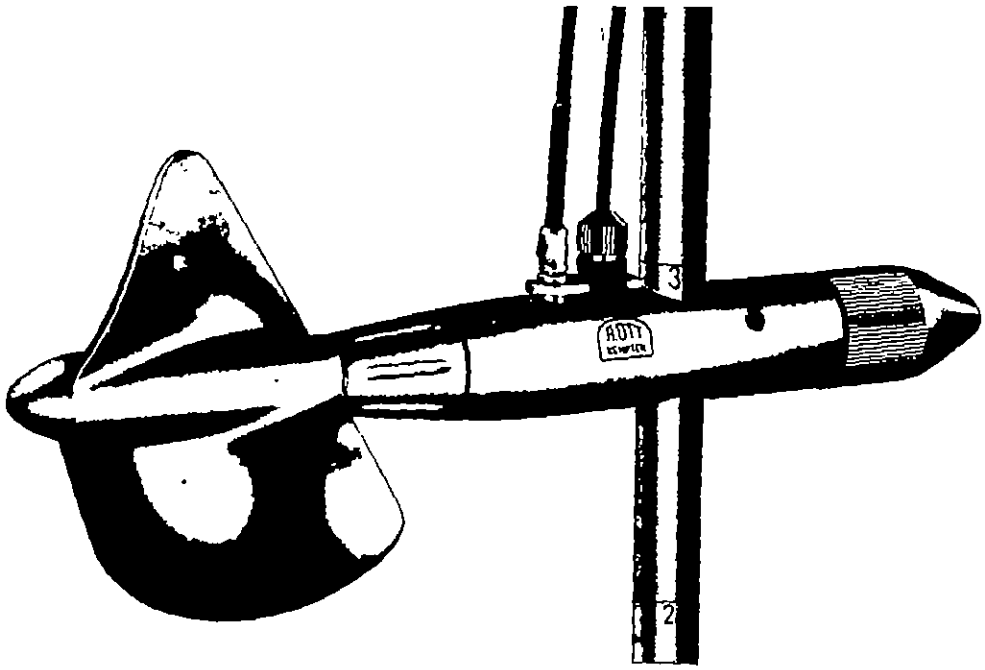


Figure A

Propeller Ref No for ordering	Propeller Type No. engraved	Propeller diameter mm	Propeller diameter in	Propeller pitch m	Propeller pitch in	Max. flow velocity of water m/sec	Max. flow velocity of water ft /sec	Starting speed m/sec
10 001 030 4.4	4	80	3 5/32	0 125	4 59/64	1 25	4 1	0.04
10 001 027 4 4	1	125	4 59/64	0.250	9 54/64	2 50	8.2	0 03
10 001 028 4.4	2	125	4 59/64	0 500	19 11/16	5 00	16.4	0 04
10 001.029 4.4	3	125	4 59/64	1.000	39 3/8	10.00	32 8	0 05
10 001 031 4 2 Component propeller up to 45° oblique flow	A	100	3 121/128	0 120	4 29/40	2 50	8 2	0 04
10 001.032 4 4 Component propeller up to 15° oblique flow	R	100	3 121/128	0.240	9 9/20	5 00	16 4	0 05

device; continuous recording of flow velocity on a compensating recorder (especially suitable for permanently installed velocity meters); and recording of the measured value by a portable, battery-powered mini-recorder (basically used with non-permanent meter installations).

Flowmeters - Epic offers the Type 22.001 "flowmeter" for indicating, recording, and counting the discharge at measuring weirs or open channels and in unpressurized pipe lines. A venturi flume can be provided with this unit. A water level-recorder with an electrical output (0-10 volts) is used as the measuring transmitter for the water level. Various systems of level meters can be employed -- e.g., pressure level gage, tube level gage, pressure level gage with transmitter-amplifier, float-type level gage, etc. Figures B through F show some typical applications of this meter. The Model 22.001 combines a direct reading indicator, counter, and strip recorder within a single cabinet.

1. Metering with the pressure level gage

A pressure transmitter is fastened on the bottom of the measuring channel. The device operates as an inductive measuring value sender. The mechanical part of the measuring value sender is a metal membrane. The deformation of the metal membrane resulting from the pressure of the water column standing over the sender is a function of the water height H. This deformation which lies for the nominal range in the magnitude of less than 0.2 mm is measured with an inductive measuring transformer and, over corresponding electronics, converted into a voltage of 5 volts for the nominal range.

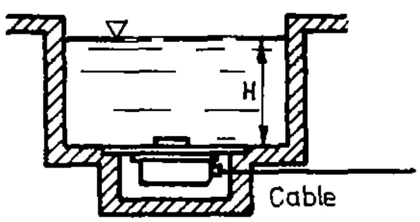


Figure B

2. Tube level gage (I)

In very muddy channels it is occasionally necessary, to clean the pressure level gage. In this case, the tube level gage is especially suitable. Here the inductive pressure transmitter is in the lower part of a tube. The sender is designed in such a way as not to touch the liquid of the measuring channel. For cleaning, the tube level gage is simply taken out of the liquid. The measuring amplifier can be fixed